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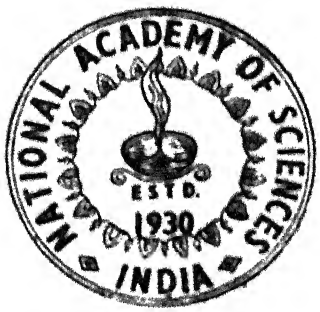

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SOME OBSERVATIONS ON THE BIOLOGY OF OXYRHACHIS TARANDUS FABR.

By

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[Received on 29th November 1958]

I. INTRODUCTION

Funkhouser (1917) was the first to publish an elaborate and useful description dealing with the biology of membracids of Cayuga lake basin. Pelaez (1945) gave principal morphological details of twelve Mexican species together with their biology and their geographical distribution. In India Chatterjee (1914) was the first to publish a short note on *Oxyrhachis tarandus* Fabr. Behura (1951) studied the host-plants, habits, economic importance and attendants of *Otionotus oneratus* Walk. Owing to the paucity of the information about the biology of Indian membracids, the author has endeavoured to describe in some detail the biology of a common membracid (*Oxyrhachis tarandus* Fabr.)

II. MATERIAL AND METHOD

The studies on the life history were made on a few *Acacia arabica* (Babool) plants about 2 to 4 feet in height. Each plant had a good number of insects and the author could, therefore, easily select and confine single gravid female on separate small twigs. The nymphs were prevented from migrating to other branches by binding the base of each branch with antiseptic cotton swab. Each female under observation was numbered by fixing a small tin plate close to it. Near about 150 females were thus observed and a complete record of oviposition was maintained. Care was taken not to allow any overlapping of broods. Metereological records of the days were also kept and their influence on the insects and their behaviour could thus be easily studied.

III. HOST-PLANTS

Oxyrhachis tarandus Fabr. has been recorded from the following plants :—

Am (*Mangifera indica* Linn.)	(Anacardiaceae)
Amaltas (*Cassia fistula* Linn.)	Caesalpinoideae
Babool (*Acacia arabica* Willd)	Mimosoideae
Jhand (*Prosopis spicigera* Linn)	do.
Kikar (*Prosopis juliflora* D.C.)	do.
Jangal jalebi (*Pithecellobium dulce* Roxb.)	do.
Siris (*Albizia lebbek* Benth.)	do.
Jait (*Sesbania aegyptiaca* Pers.)	Papilionatae
Sem (*Dolichos loblab* Benth.)	do.
Sanai (*Crotalaria juncea* Linn.)	do.
Arhar (*Cajanus indicus* Spring.)	do.
Imli (*Tamarindus* indica Linn.)	do.
Ber (*Zizyphus jujuba* Lamb.)	Rhamnaceae
Jharberi (*Zizyphus rotundifolia* Lamb.)	do.
Baigan (*Solanum melongena* Linn.)	Solanaceae

IV. BIOLOGY

Habit :—These insects have been usually seen on scattered plants growing in the open. When plants like Arhar (*Cajanus indicus* Spring.), Sanai (*Crotalaria juncea* Linn.), *Sem* (*Dolichos lablab* Benth.), Baigan (*Solanum melongena* Linn.) are growing in the fields, only a few plants are attacked. They constantly change their position with the movement of the sun as they do not like direct sun light. They prefer to live on young plants with smooth bark and do not move into the crevices of the bark as reported by Behura (1951) in *Otionotus oneratus*. On bushy plants like Kikar (*Prosopis juliflora* Dc.), the nymphs and freshly moulted adults descend down very close to the ground and sometimes enter the nest of the common black ant (*Camponotus copmpressus* Fabr.). A large majority of the adults sit with their heads directed towards the growing point of the branch (Table no. 1). The nymphal instars move towards the growing point of the branch or petiole of young leaf where it is easier to pierce the soft bark. After the second moult, they begin to move towards the base of the branch and start living gregariously. They are most active during the warmest part of the winter, throughout the day except mid-day in summer and all the day in rains.

Table No. 1. Showing the sitting posture of *O. tarandus* Fabr. on a branch.

No. of obs.	Host-plant	Locality	No. of insects with their heads directed towards base of the branch	No. of insects with their heads directed towards the growing point of the branch	Date of observations
1	*A. arabica*	Khandari farm	5	11	1.10.54
2	do.	do.	3	25	7.10.54
3	do.	do.	9	39	1.11.54
4	*Prosopis juliflora*	College campus	3	23	10.11.54
5	*Acacia arabica*	Khandari farm	6	20	14.11.54
6	do.	do.	5	17	14.11.54
7	do.	do.	4	9	14.11.54
8	*Prosopis juliflora*	College campus	10	27	16.11.54
9	*A. arabica*	do.	13	64	18.11.54
10	do.	Khandari canal	14	59	18.11.54
11	do.	do.	5	34	19.11.54
12	do.	do.	7	20	19.11.54

Mating :—Pairing begins soon after the insect reaches sexual maturity. Usually a number of males ride over a female, looking forward for the opportunity and grasping the female within their forelegs for several hours. Only one succeeds and when engaged, the male turns round in such a way that the two insects point to the opposite directions and their posterior ends remain in contact. They remain in this condition for about an hour.

Oviposition :—Soon after copulation the female usually selects a place on the lower surface of the branch far removed from the sun light three to twelve months old about 8 to 16 mm. in diameter. It makes a slightly horizontal straight incision in the bark at an angle of 30° to 40° to the long axis of the twig. A flap of superficial bark thus encloses a cavity in which the female glues its eggs in a line. Another incision at an angle of 60° to 80° to the first is made and eggs similarly deposited. New incisions are parallel to these. The whole area appears to show numerous V-shaped incisions partly overlapping the preceding ones (Fig. 1.). The usual number of eggs present in an arm of "V" is between eight to ten, although, the maximum may be twenty-three. The maximum number of eggs laid by a female during one oviposition period may run to two hundred and seventy-five and the length of the egg-mass varies from 0·4" - 0·6" (Tables II and IV). The egg-mass of this species can be readily differentiated from other two species of membracids, *i. e. Otionotus oneratus* Walk. and *Leptocentrus taursu* Fabr. The entire egg-mass of *O. oneratus* consists of 50 to 60 irregularly arched incisions (Fig. 2). Each incision carries 5 to 6 eggs. The female of *L. taurus* makes numerous deep arched incisions. The eggs are not visible from outside. Normally ten to twelve eggs are enclosed in each incision (Fig. 3).

Table No. 2 indicating the number of eggs present in different arms of the egg-masses of *O. tarandus* Fabr.

No. of rows	Egg-mass No. 1		Egg-mass No. 2		Egg-mass No. 3		Egg-mass No. 4		Egg-mass No. 5		Egg-mass No. 6		Egg-mass No. 7	
	Left arm	Right arm	Left arm	Right arm	Left arm	Right arm	Left arm	Right arm	Left arm	Right arm	Left arm	Right arm	Left arm	Right arm
1	16	14	12	17	14	15	5	6	10	9	10	9	8	7
2	10	14	11	14	17	9	6	6	11	16	12	9	10	5
3	12	11	13	16	16	15	5	9	8	19	8	11	8	6
4	7	10	14	3	9	6	6	7	8	20	11	10	9	7
5	8	8	10	13	4	11	5	6	3	4	9	9	6	7
6	8	6	7	10	9	12	6	6	15	12	7	9	0	9
7	5	3	12	11	11	8	6	6	4	10	5	8	0	6
8	9	10	12	11	11	9	6	5	17	8	5	0	0	11
9	5	9	13	6	7	10	7	5	8	8	7	0	0	0
10	2	9	10	10	13	11	5	4	9	10	0	0	0	0
11	0	5	10	9	11	0	5	5	10	0	0	0	0	0
12	0	8	9	3	0	8	0	8	10	0	0	0	0	0
13	0	0	10	9	5	0	4	0	0	0	0	0	0	0
Total No. of eggs	82+107 =189		143+132 =275		127+114 =241		66+73 =139		113+116 =229		74+65 =139		41+58 =99	

Structure of the egg :—The eggs are elongate, 0·133 cm. long and 0·018 cm. in breadth (Fig. 4). The author could not notice any process at the enclosed end as reported by Chatterjee (1914). When freshly laid, each egg is bluish-white but changes to light orange after a day or two and subsequently a black large circular spot appears at the exposed end of the egg.

Incubation period :—This is subject to variation depending upon the season and climatic conditions. During monsoon it ranges between 7 to 14 days, in winter 30 to 62 days and in summer 10 to 20 days (Table no. 3).

Nymphal stages :—There are five nymphal stages in the life cycle of this insect. The duration of these stages varies according to the season. The average nymphal period during the different seasons is as given in the table no. 4. It is 65 to 77 days in winter, 22 to 37 days in summer and 16 to 21 days in rainy season.

Table No. 3 indicating the incubation period.

Season	Egg-laying starts on	Eclosion	Time
W	11.11.54	13.12.54	33 days
i	16.11.54	16.12.54	31 do
n	17.11.54	13.1.55	57 do
t	23.11.54	25.1.55	51 do
e	25.11.54	25.1.55	62 do
r	26.11.54	13.1.55	49 do
S	10.3.55	4.4.55	26 do
u	15.3.55	6.4.55	23 do
m	17.3.55	31.3.55	15 do
m	27.45.5	14.5.55	18 do
e	29.4.55	13.5.55	13 do
r	1.5.55	10.5.55	11 do
	3.5.55	10.5.55	8 do
R	16.6.55	23.6.55	8 do
a	20.6.55	26.6.55	7 do
i	23.6.55	6.7.55	14 do
n	2.7.55	14.7.55	13 do
s	5.7.55	16.7.55	12 do
	16.8.55	26.8.55	11 do

Table No. 4 indicating the total nymphal period during different seasons.

Season	Hatching starts on	Adult emerges on	Time taken
W	19.12.54	26.3.55	66 days
i	20.12.54	26.3.55	65 do
n	12.1.55	17.3.55	64 do
t	14.1.55	31.3.55	77 do
e	20.1.55	30.3.55	69 do
r	26.1.55	4.4.55	68 do
S	28.3.55	4.5.55	38 do
u	31.3.55	2.5.55	35 do
m	4.4.55	10.5.55	37 do
m	5.5.55	4.6.55	30 do
e	10.5.55	2.6.55	23 do
r	13.5.55	3.6.55	22 do
R	26.6.55	12.7.55	17 do
a	28.6.55	14.7.55	17 do
i	30.6.55	15.7.55	16 do
n	4.7.55	20.7.55	17 do
s	6.7.55	24.7.55	19 do
	7.8.55	23.8.55	17 do
	10.8.55	30.8.55	21 do

First instar :—(Fig. 5). Length 0·1 cm. and breadth 0·05 cm. Extremely soft bodied, shining and light brown when freshly hatched. Head deflexed, longer than broad, sparsely beset with bristles ; labium reaching upto the 5th abdominal sternite ; labrum grey, extending upto third labial segment ; vertex raised into two sharp conical processes each bearing a fine bristle at its summit ; epicranial suture distinct ; ocelli absent ; antennae beaded-shaped, three segmented, terminal segment largest broad at the base and abruptly tapering at the distal end without hair ; prothorax larger than the other segments of pterothorax ; pleurites imperfectly developed ; wing-pads absent ; legs brown black ; coxa and femur cylindrical ; tibia flat ; tarsi two segmented ; abdomen light black smooth, sparcely beset with bristles, nine segmented.

Second instar :—(Fig. 6). Length 0·27 cm. and breadth 0·1 cm. Head deflexed ; frontoclypeus as long as broad and more convex ; epicranium raised into an outgrowth near the eyes bearing fine small bristles at its summit ; a median dorsal pronotal spine appears overlapping a part of the succeeding segments ; meso and meta wing-pads distinct ; thoracic pleura distinct and each divided into epimeron and episternum.

Third instar :—(Fig. 7). Length 0·3 cm. and breadth 0·16 cm. Head and thorax similar to that in the second instar ; median dorsal pronotal spine enlarges and extends upto about one third of the mesonotum, abdomen marked with broad and light black bands on dorsal side and alternating thin yellow and light black bands on the lateral sides ; minute ventrolateral tergal expansions on fifth to eighth abdominal segments.

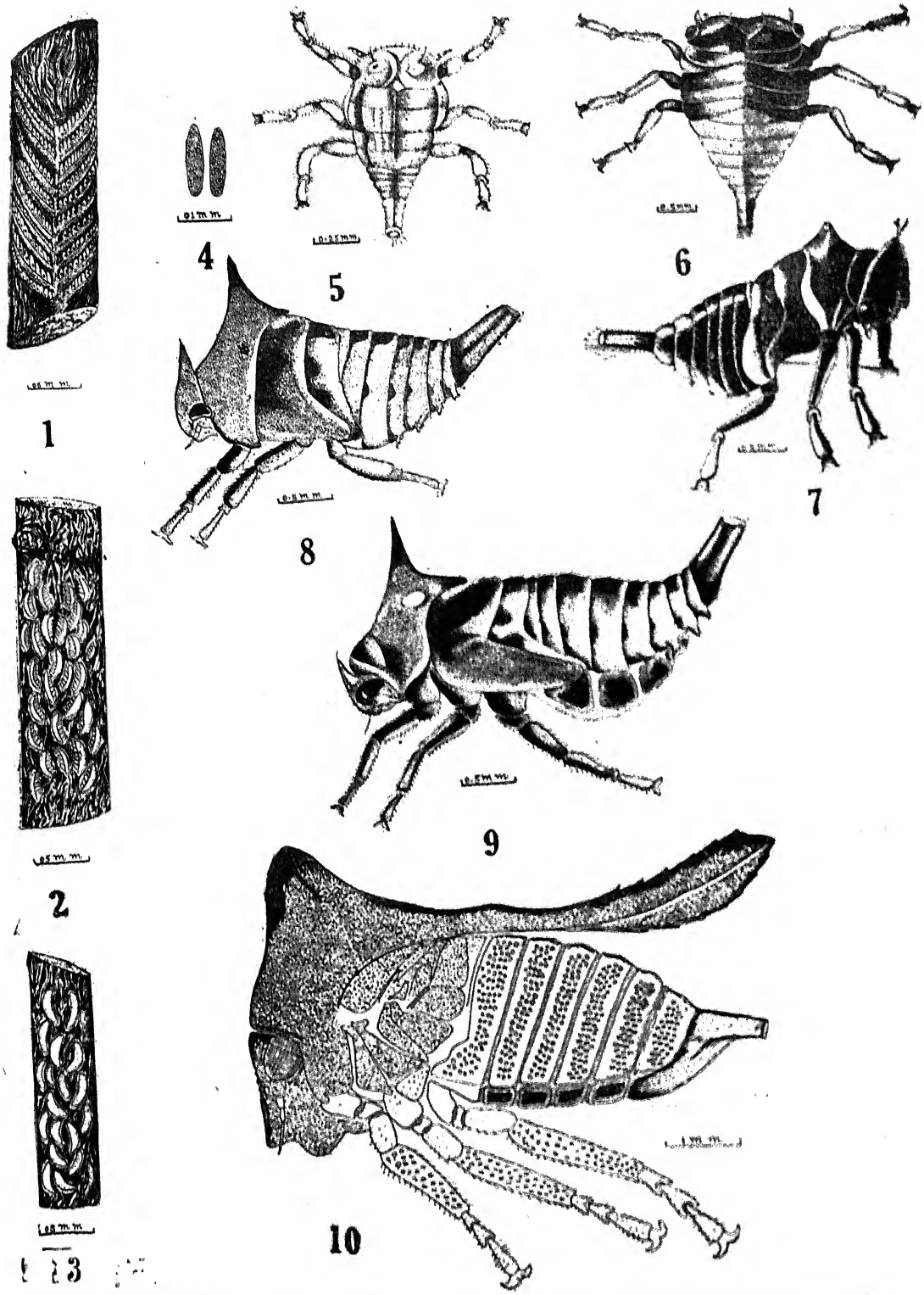

Fig. 1. Egg-mass of *Oxyrhachis tarandus* Fabr.
Fig. 2. Egg-mass of *Otinotus oneratus* Walk.
Fig. 3. Egg-mass of *Leptocentrus taurus* Fabr.
Fig. 4. Eggs of *O. tarandus* Fabr.
Fig. 5. First nymphal instar of *O. tarandus* Fabr.
Fig. 6. Second nymphal instar of *O. tarandus* Fabr.
Fig. 7. Third nymphal instar of do.
Fig. 8. Fourth nymphal instar of do.
Fig 9. Fifth nymphal instar of do.
Fig. 10. Adult of *O. tarandus* Fabr. (wings removed)

N. B.—First, second and third nymphal instars after Lefroy 'Indian Insect Life'

Fourth instar :—(Fig. 8). Length 0·4 cm. and breadth 0·34 cm. Frontoclypeus more bulged ; distal segments of antennae longer than the rest ; epicranium overhanging in front of antennae ; ocelli present, frontal process further enlarged ; a yellow spot appears at the base of frontal process ; mesothoracic wing-pads grow larger completely overlapping the metathoracic segment ; ventrolateral tergal expansions on fifth to eighth segments become prominent bearing a number of bristles.

Fifth instar :—(Fig. 9). Length 0·5 cm. and breadth 0·35 cm. Head profusely beset with bristles ; frontoclypeus highly convex ; epicranium distinctly overhanging antennal base ; ocelli distinct ; frontal process overhaning two third of the mesothorax ; mesothoracic wing-pads further enlarge reaching fourth abdominal segment ; ventrolateral tergal expansions of fifth to eighth highly developed and bristles present on short protuberances.

Seasonal history :—Five generations of this insect have been recorded to occur in a year. It becomes very difficult for these insects to withstand the extreme high and low temperatures during the months of May/June and January. When the day temperature touches 113°F. in the last week of May and the first week of June, about 90% of these insects die. A limited number survive on branches of small bushy *Acacia arabica* (Babool) plants not directly exposed to hot winds. With the advent of rains in the third week of June, hoppers become active and start mating and laying eggs. Two generations pass before the advance of winter. During low temperatures their activities are confined to the warmest part of the day. Hoppers feed, mate and lay eggs almost throughout winter except a few weeks in December and January when the night temperature falls to 38°F. The adults mostly succumb to this temperature. Quite a good number of eggs become parasitised. The nymphs that hatch during December and early weeks of January either die due to cold or are killed by spiders. As a rule hatching of the eggs starts in the second week of March. Fourth and fifth generations pass quickly before the advent of hot winds of summer (Table no. 5).

Table No. 5 indicating various generations of *O. tarandus* Fabr.

Generation	Plate No.	Oviposition period		Hatching starts on	Adult emerges on	Length of Egg-mass	Remark
		Egg-laying starts on	Egg-laying ends on				
	2	8.11.54	10.11.54	—	—	.1 inch	
F	5	8.11.54	25.11.54	11.12.54	20.3.55	·4 do.	
	8	9.11.54	30.12.54	—	—	·6 do.	
I	12	10.11.54	16.12.54	10.12.54	—	·5 do.	
	14	10.11.54	9.12.54	3.12.54	21.3.54	·6 do.	
R	16	10.11.54	20.12.54	5.12.54	—	·6 do.	
	20	11.11.54	24.12.54	13.12.54	27.3 55	·6 do.	
S	30	12.11.54	26.12.54	13.12.54	25.3.55	·4 do.	
	33	16.11.54	10.12.54	21.1.55	30.3.55	·4 do.	
T	36	16.11.54	9.12.54	13.1 55	22.3.55	·6 do.	
	40	16.11.54	6.12.54	12.1.55	17.3.55	·6 do.	
	44	17.11.54	5.12.54	13.1.55	31.3.55	·4 do.	
	50	19.11.54	5.12.54	10.1.55	22.3.55	·5 do.	
	54	20.11.54	5.12.54	19.12.54	25.3.55	·6 do.	
	56	20.11.54	6.12.54	19.12.54	26.3.55	·2 do.	
	60	26.11.54	6.12.54	26.1.55	4.4.55	·3 do.	

Table No. 5 indicating various generotion of *O. tarandus*—*(concld.)*

Generation	Plate No.	Oviposition period		Hatching starts on	Adult emerges on	Length of Egg-mass	Remark
		Egg-laying starts on	Egg-laying ends on				
S	63	10.3.55	10.4.55	4.4.55	10.5.55	·5 inch.	
	68	10.3.55	26.4.55	28.3.55	4.5.55	·6 do.	
E	72	11.3.55	28.3.55	31.3.55	3.5.55	·4 do.	
	80	12.3.55	28.3.55	31.3.55	25.5.55	·5 do.	
C	83	12.3.55	21.3.55	22.3.55	4.5.55	·3 do.	
	86	14.3.55	15.4.55	31.3.55	4.5.55	·6 do.	
O	90	15.3.55	14.4.55	6.4.55	7.5.55	·4 do.	
	94	17.3.55	24.4.55	31.3.55	6.5.55	·5 do.	
N	98	18.3.55	26.3.55	—	—	·3 do.	Parasitised
D	101	22.3.55	30.3.55	31.3.55	10.5.55	·3 do.	
T	103	28.4.55	5.5.55	15.5.55	4.6.55	·5 inch.	
H	105	29.4.55	4.5.55	10.5.55	2.6.55	·3 do.	
I	107	1.5.55	2.6.55	10.5.55	3.6.55	·6 do.	
R	109	1.5.55	6.5.55	13.5.55	3.6.55	·3 do.	
D	110	1.5.55	8.5.55	13.5.55	5.6.55	·4 do.	
	111	3.5.55	8.5.55	10.5.55	4.6.55	·4 do.	
F	112	16.6.55	2.7.55	23.7.55	25.7.55	·5 inch	
O	113	18.6.55	8.7.55	25.6.55	31.7.55	·4 do.	
U	114	20.6.55	25.6.55	27.6.55	24.7.55	·3 do.	
R	115	20.6.55	18.7.55	26.6.55	12.7.55	·5 do.	
T	118	21.6.55	24.6.55	28.6.55	14.7.55	·2 do.	
H	119	21.6.55	—	28.6.55	14.7.55	·5 do.	
	120	21.6.55	7.7.55	27.6.55	16.7.55	·5 do.	
	121	23.6.55	11.7.55	6.7.55	25.7.55	·4 do.	
	125	3.7.55	17.7.55	15.7.55	5.8.55	·6 do.	
F	127	24.7.55	—	2.8.55	26.8.55	·3 inch.	
I	129	31.7.55	—	13.8.55	19.8.55	·4 do.	
F	132	2.8.55	24.8.55	16.8.55	9.9.55	·5 do.	
T	135	9.8.55	19.8.55	18.8.55	20.9.55	·3 do.	
H	137	15.8.55	26.8.55	22.8.55	22.9.55	·6 do.	
	139	16.8.55	28.8.55	24.8.55	31.9.55	·7 do.	
	142	17.8.55	25.8.55	26.8.55	25.9.55	·4 do.	
	145	29.8.55	—	8.9.55	8.10.55	·6 do.	
	148	30.8.55	—	14.9.55	15.10.55	·5 do.	

V. ATTENDANCE BY ANTS.

The adults and nymphs of all species of membracids are attended by a number of Hymenopterous insects. Their association has been studied by Wheeler (1917), Funkhouser (1917), Behura (1951) and others. The author has observed that the attending insects are of two types, *i. e.*, casual and permanent attendants. Yellow wasp (*Polistis habraeus* Fabr.) and Hornet (*Vespa orientalis* Linn.) are among the casual attendants. The permanent visitors belong to family Formicidae. The most important are common large black ant (*Componotus compressus* Fabr.), small black ant (*Monomorium gracillium*), small brown ant (*Prenolepis* sp.) and common harvestor ant (*Messor* sp.).

The casual attendants visit these insects from September to November. These visitors hover round the hoppers in large numbers and feed on the honey-dew. Only one type of the permanent visitor attends a single host-plant. No sooner a new colony of adult membracids establishes itself on a new host-plant and passes out honey-dew, the ants smell honey-dew and immediately attend on them within less than three hours. The common large black ants (*Componotus compressus* Fabr.) strike the membracids by their antennae in rapid succession till the latter pass out a droplet of honey-dew, which is colourless, heavy, sticky, sweet and its chemical examination proves the presence of sugars. They immediately lick the honey-dew and repeat the process of striking to get a further supply. It is quite possible that the movement of small ants over the hosts is sufficient to induce them to discharge a droplet of honey-dew.

The ants attend the host throughout the day and night irrespective of weather. Their activity decreases during extreme cold winter nights. They act as vigilant watch dogs of these insects as they are quick to detect any danger and begin running about in confusion. They give a timely signal to the hoppers. They also provide protection against spiders, Reduvid bugs, Hymenopterous parasites and ticks. During rains the author has noted the common large black ants making mud shelters at the confluence of several branches and a large number of adults and nymphs of *O. tarandus* Fabr. have been seen taking refuge in these temporary houses. Their absense is definitely detrimental to the healthy development of the colony. Owing to the continuous development of the honey-dew without any arrangement for scavanging, the nymphs get entangled within their own secretion. Their movements are restricted and sometimes their spiracles are chocked. The accumulation of honey-dew encourages the growth of the fungus, which too may bring about the death of the hoppers.

VI. ENEMIES OF MEMBRACIDS

All the stages in life-cycle of these hoppers are subjected to destructive activities of various enemies. The eggs are mostly parasitised by a minute chalcid wasp especially during winters when the low temperature retards the activities of their attendants. This affords sufficient opportunity for these parasites to lay their eggs after piercing the egg-shell of membracids. Parasitised eggs become black. The parasitic imago cuts a round hole at the exposed end of the egg. Other Hymenopterous parasites are also rarely met within the abdomen of the adult hoppers. Red mites are severe ectoparasites of the adult and nymphs. The spiders and Reduvid bugs are responsible for a heavy toll of their nymphal stages specially during winter season when they are left uncared for by their attendants. Nematodes have also been collected from the body cavity of the adults. The common Indian lizard (*Calotes versicolor*) is a voracious feeder on black ants and in

association with them a heavy number of membracids also fall a prey. During winter rains, the egg-masses are severely attacked by a black fungus. The mycelia circumscribe the eggs very intimately allowing no room for development.

VII. SUMMARY

Oxyrhachis tarandus Fabr. has been recorded from fifteen plants belonging to four families (Leguminoseae, Anacardiaceae, Rhamnaceae and Solanaceae). Adults and nymphs have been found on young plants growing in the open. Oviposition, spreading over a number of weeks, takes place in superficial cuts in the lower surface of the bark unexposed to direct sun light and large number of eggs are glued in V-shaped patterns. The hatching period varies with the season, *i.e.*, 31 to 62 days in winter and 8 to 26 days in rest of the year. The time taken by five nymphal stages to become adults also varies with the season, *i. e.*, 64 to 77 days in winter, 21 to 41 days in summer and 16 to 21 days in rains. Five generations have been recorded in a year. It becomes very difficult for these insects to withstand the extreme high temperature, *i. e.*, 113°F, during the months of May and June and low temperature, *i. e.*, 38°F during the month of January. During this period most of the hopper population is wiped off. These insects are attended by a number of Hymenopterous insects, *viz.*, Hornet (*Vespa orientalis*), Yellow wasp (*Polistis habraeus*), Common large black ant (*Componotus compressus*), small black ant (*Monomorium graciliium*) and small brown ant (*Prenolepis* sp.) and a common harvestor ant (*Messor* sp.). Their attendance is necessary for healthy growth of the colony. Eggs are heavily parasitised by a chalcid parasite during winter season. Hymenopterous parasites have also been recorded within the abdomen of the adult hoppers. Red mites are ectoparasites of adults and nymphs. Reduvid bugs and spiders destroy quite a number of nymphs.

VIII. ACKNOWLEDGEMENT

The author is extremenly thankful to Dr. R. D. Saksena, Head of the Department, B. R. College, Agra, for his valuable guidance and to Dr. R. N. Mathur, Chief Research Officer, Forest Research Institute, Dehradun, and Dr. A. P. Kapoor, Officer-in charge, Entomology section, Zoological Survey of India, for identifying various insects.

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STUDIES ON THE MORPHOLOGY AND LIFE HISTORY OF CLINOSTOMUM PISCIDIUM SOUTHWELL AND PRASHAD, 1918. (TREMATODA: CLINOSTOMATIDAE)

By

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INTRODUCTION

Our knowledge of the Indian forms belonging to the family Clinostomatidae is incomplete in many respects and exhaustive work on the morphology and life history of these parasitic worms is required. Importance has been attached to these worms for some time past because of the consideration that heavy infection renders host fishes unpalatable as food. The question of controlling these parasites has, therefore, become essential in the interest of the fish industry. Further, the life history of Clinostomes becomes all the more significant and interesting since it combines the characters of blood flukes and strigeid trematodes.

The present paper deals with morphology and life history of *Clinostomum piscidium* which was originally described as a metacercerial form by Southwell and Prashad (1918) and later by Bhalerao (1942).

SYNONIMITY OF THE SPECIES

A short account of the morphology and life history of a new species *Clinostomum microstomum* n. sp. was published by the author (1955) in the Abstracts of the Business Matters of the National Academy of Sciences, India. The new species was differentiated from *C. piscidium* to which alone it resembles on the basis of two characters : the nature of vitellaria and the contents of the cirrus sac. In *C. piscidium*, the vitellaria extend posteriorly from the region of the anterior testis and end a little before the ends of intestinal caeca. The worms possess vesicula seminalis interna as well as externa. Further studies on *C. microstomum* Singh, 1955 have revealed that in general the vitelline follicles are not well differentiated in the metacercariae, but in those in which they are clear, their nature is similar to that in *C. piscidium*. When the metacercariae metamorphose into the adults, the vitelline follicles become differentiated and extend posteriorly from the distal margin of the ventral sucker to a little above the ends of intestinal caeca. Further, there is only vesicula seminalis interna instead of externa both in the metacercariae and in the adults. The observation of Southwell and Prashad (1918) on vitellaria and vesicula seminalis are based only on the study of metacercariae and, therefore, is incomplete. Further, the presence of a vesicula seminalis externa has not been reported so far in the family Clinostomatidae.

The measurements and other morphological details as well as the biology of *C. microstomum* Singh, 1955 are identical to *C. piscidium* Southwell and Prashad, 1918 and there is no sound basis for regarding the former as a distinct species from the latter. Therefore, the name, *C. microstomum* is suppressed as a synonym of *C. piscidium*.

PREVIOUS WORK

The family Clinostomatidae was created by Luhe (1901) to include the genus *Clinostomum* Leidy, 1856. Pratt (1902) erected the subfamily Clinostomatinae under the family Clinostomatidae for the genus *Clinostomum*. Travassos (1928) included another genus *Euclinostomum* for the reception of *E. heterostomum* (Rudolphi, 1809). Dollfus (1950) described a new genus *Clinostomoides* with the type species *C. brieni* under the subfamily Clinostomatinae Pratt, 1902. In this paper he has recognized five genera in the family Clinostomatidae. They are : *Clinostomum* Leidy, 1856 ; *Ithyclinostomum* Witenberg, 1925[1] ; *Clinostomatopsis* Dollfus, 1932 ; *Clinostomoides* Dollfus, 1950 and *Euclinostomum* Travassos, 1928.

In the genus *Clinostomum* eighteen species have been described so far in the adult stage. They are : *Clinostomum complanatum* (= *C. marginatum* Rud. 1809) Braun, 1901 ; *C. detruncatum* Braun, 1899 ; *C. foliiforme* Braun, 1899 ; *C. heluans* Braun, 1899 ; *C. lambitans* Braun 1899 ; *C. sorbens* Braun, 1899 ; *C. attenuatum* Cort, 1913 ; *C. hornum* Nicoll, 1914 ; *C. australiense* Johnston, 1916 ; *C. intermedialis* (Lamont, 1920) Price, 1938 ; *C. pusillum* Lutz, 1928[2] ; *C. phalacrocoracis* Dubois, 1930 ; *C. lophophallum* (= *C. lophocirrum* Baer, 1933) Baer, 1933 ; *C. vanderhorsti* Ortlepp, 1935 ; *C. anusi* wesley, 1944 and *C. ophiocephali* Tubangui and Masilungun, 1944. The validity of the species *C. pusillum* Lutz, 1928 ; *Clinostomum* sp. Belliappa, 1944 and *C. katappahi* Bhalerao, 1947 is doutful because of insufficient descriptions.

The species of the genus *Clinostomum* known in the metacercraial stage are ; *C. gracile* Leidy ; 1856 ; *C. dictyotum* Monticelli, 1893 ; *C. africanum* Galli-Valerio, 1906 ; *C. piscidium* Southwell and Prashad, 1918 ; *C. chrysichthys* Dubois, 1930 ; *C. dalagi* Tubangui, 1933 ; *C. pseudoheterostomum Tubangui*, 1933 ; *C. prashadi* Bhalerao, 1942 ; *C. dasi* Bhalerao, 1942 ; *C. gideoni* Bhalerao, 1942 ; *C. indicum* Bhalerao, 1943 and *C. schizothoraxi* Kaw, 1950.

In the genus *Euclinostomum* Travassos, 1928 only four species are known. They are : *E. heterostomum* (Rud) ; *E. clarias* Dubois, 1929 ; *E. multicaecum* Tubangui and Masilungun, 1935 and *E. indicum* Bhalerao, 1942.

Hunter and Hunter (1934, 35) described the life history of *C. marginatam* In 1935, they published notes on the penetration and growth of *Cercaria C. marginatum* in the fish hosts and also gave the account of miracidium showing that it has four flame cells and 21 epidermal plates like those of strigeids and schistosomes. Krull (1934) described the morphology of the cercariae of *C. marginatum* from natural infections of *Helisoma antrosa* and also reported the growth of metacercariae in the fish *Eupomotis gibbosus*. The cercariae were reported to be like those of strigeids and blood-flukes. Yamaguti (1934) described the anatomy of *C. complanatum* along with a short account of its peculiar miracidium. Srivastava (1950) published a preliminary note on the life cycle of a *Clinostomum* sp. and *Euclinostomum* heterostomum (Rud.) from India.

Singh (1952) described a new species of *Clinostome* cercaria. *Cercaria (Clinostome) hunterii* from the snail *Indoplanorbis exustus* (Deshayes) and created a group of "Clinostome Cercariae" to include the cercaria of *C. marginatum*, *C. brevifurca* McCoy, 1928 ; *C. whitentoni* Croft, 1934 and *C. bombayensis* no. 8 Soparkar, 1921.

1, 2.—These references were not consulted in original.

1. Consulted from Dollfus (1950).

2. Consulted from Price (1938).

The studies of Hunter and Hunter (1934, 35) and of Krull (1934) were the first to show that the miracidia and cercariae of *C. marginatum* manifest striking similarity with those of the strigeids and blood-flukes, although a redial stage is present in the life cycle. These observations led La Rue (1938) to recognize genetic relationship between the Clinostomatidae and the Strigeids and the blood-flukes. He, therefore, proposed that the family Clinostomatidae should be placed in the order Strigeatoidea La Rue, 1926. Allison (1943) compared the structure and life history of *L. constantiae* (Mueller) with representatives of Strigeata, Bucephalata, Schistosomata and Clinostomata and concluded that the family Brachylaemidae is genetically related to the Strigeatoidea. He, therefore, placed *C. marginatum* in a new suborder Clinostomata under Strigeatoidea. In the same paper, he created the super-family Brachylaemoidea for the family Brachylaemidae. Joyeux and Foley, 1930 for which Mehra (1950) created the suborder Brachylaemata. As such, the order Strigeatoidea La Rue, 1926 contains the five suborders Strigeata La Rue, 1926; Schistosomata La Rue, 1926; Bucephalata La Rue, 1926; Clinostomata Allison, 1943 and Brachylaemata Mehra, 1950.

MATERIAL AND METHOD

The various stages in the life history of *C. piscidium* were studied from natural as well as experimental infections in the laboratory. The work on the metacercariae was based only from natural infections of the fishes *Nandus nandus*, *Belone cancilla* and *Ophiocephalus punctatus* collected from ponds at Jabalpur and Raipur in M. P. The adult worms were obtained by feeding metacercariae to three species of herons : *Egretta garzetta* (Linn.), *Ardeola grayii* (Sykes) and *Bulbulcus ibis* (Linn.). Natural cases of adult infections were recorded in the above three species of herons and also in the night heron *Nycticorax nycticorax nycticorax*. The work on the egg, miracidium and cercariae was based exclusively upon the living material from experimental infections.

EXPERIMENTAL INFECTIONS AND OBSERVATIONS

Experiment with the avian hosts :

On July 21, 1955 one *Ardeola grayii* was fed 10 metacercariae taken out from one specimen of *Nandus nandus*. After 12 hours the worms were found to be attached to the lower surface of the tongue and on the trachea. One worm was removed from the mouth on 24th. July, and the remaining on the 28th. In all, eight worms were taken out, two failed to develop.

In the second experiment laid on July, 31 1955, 36 metacercariae were removed from the body cavity of a fish and two herons, *Bulbulcus ibis coromandus* were fed each with 18 worms. From the first, 18 worms were recovered on 5th. August and from the second the same number was available on 8th. In both the cases, worms passed out large number of eggs which were put in hatching flasks. Large number of miracidia were collected for study and experimental infections.

In the third experiment two *Egretta garzetta* were fed with 20 metacercariae each on 5th. August, 1955. The first bird died on 11th. August yielding 20 adults and from the second equal number of parasites were removed on the 11th. August.

The above three sets of experiments revealed that the worms mature within six days after they were introduced in the buccal cavity of birds. In subsequent

experiments, two *Ardeola grayii* which lived for about an year on fish diet were used. From these birds, large number of parasites were recovered at intervals after every feeding experiment and this gave an opportunity to study the entire life cycle of the parasite in the laboratory.

Experiments with the Molluscan Host :

Clean laboratory controlled specimens of *Indoplanorbis exustus* (Deshayes) and *Lymnaea luteola* (Lamark) were used in the experiments but the developmental stages could be obtained only from the latter species of snail.

In the first experiment, six young and clean specimens of *L. luteola* exposed to varying numbers of miracidia on 31st. August, 1955, became positive for intramolluscan stages after 12 days. In these infections, the sporocyst stage was not recovered but young as well as mature mother rediae produced by the sporocysts were found attached to a loose network of connective tissue on the intestinal tract and also in the liver. In another snail from the same lot, killed one month later, the mother rediae could not be found but 20 mature daughters with cercarial germ balls and developing cercariae in them were recovered. The remaining snails discharged cercariae after 35 days.

In the second experiment carried on 17th. and 18th. January, 1956, 55 *Indoplanorbis exustus* were exposed to miracidia but no infection was recorded in them after a month.

In the third experiment laid on 5th. March, 1956, 25 *Lymnea luteola* were exposed to varying numbers in groups. Most of the snails died before the prepatent period but five that survived for about 40 days discharged cercariae. Mature rediae and cercariae were fixed for whole mounts after their study in living state. The cercariae were like those obtained from the first experiment.

THE LIFE HISTORY

The above observations show that the life history of *C. piscidium* is like that of *C. marginatum*. The adult worms live in the buccal cavity of fish eating birds. The eggs of the parasite are passed out side with the spootum of the birds when they dip their bills in water for catching fish. The miracidia hatched from the eggs within 8-10 days, penetrate snails of the species *L. luteola* and assume the form of mother sporocysts which in turn produce large number of mother rediae. The mother rediae produce large number of daughter rediae which ultimately give rise to cercariae. The intramolluscan phase of the life cycle takes about 35-40 days. The cercariae are released by infected snails in water and attack several species of fishes. The cercariae develop into metacercariae in the body cavity of fishes without encystment. When the infected fish hosts are eaten by fish eating birds, the worms develop to sexual maturity within 5-6 days in the buccal cavity.

The Egg: (Fig. 1)

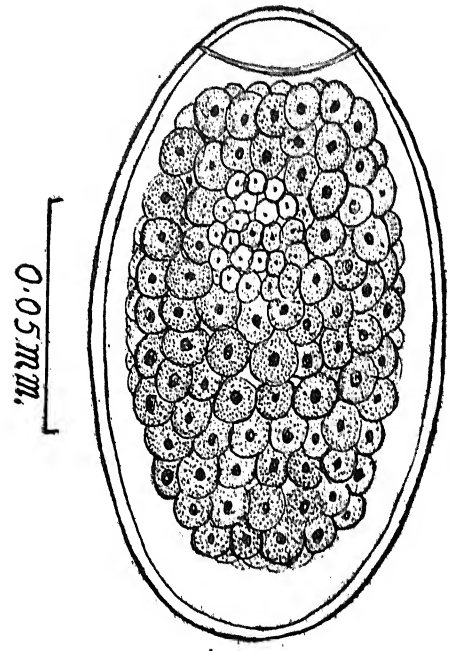

Fig. 1. Mature Egg.

The adult worms when removed from the buccal cavity of the avian hosts and on being placed in water, shed large number of eggs in definite strings as in *C. marginatum*. All the eggs deposited in this way are practically immature and there was no such instance in which the first few eggs in the string contained developed miracidia as has been reported in the case of *C. marginatum* by Hunters (1935). The eggs were first found in the spootum of the experimental birds on the 6th. day after their feeding with metacercariae.

The eggs are oval to ellyptical in outline and the length and breadth in 10 specimens measures 0·088 - 0·09 mm. (av. 0·08 mm.) and 0·048 - 0·054 mm. (av. 0·05 mm.) respectively. The shell is moderately opaque and internal to it lies a delicate vitelline membrane that encloses the embryo and the yolk cells. As the eggs are laid in an uncleaved state, they take longer period for hatching, which may vary from 8-10 days during July to September and upto 20 days in winter months. It is a common phenomena that the eggs of trematodes in general swell due to absorption of water and the hatching is caused either by absorption of water or by the activity of the miracidium or by both (Price, 1931) as well as due to some chemical factors associated with the maturity of the miracidium and its activity to free itself from the egg shell (Wall, 1941). These observations are also true for the present species.

The factors governing the hatching of eggs of the present species are similar to those described for other species of trematodes. Though, temperature is the chief controlling factor for embryonic development, the pH value of water containing the

eggs and sufficient light are equally important factors. The experiments show that at a temperature of 25°C – 30°C, pH of 7·0 – 7·5 and in sufficient light, the hatching is complete within 8-10 days. When the temperature of water is maintained at 18°C. – 20°C., the period of hatching is prolonged and takes 20 – 22 days. Cold and darkness inhibit hatching as the miracidia usually come out in bright warm hours of the day.

The Miracidium : (Figs. 2 and 3)

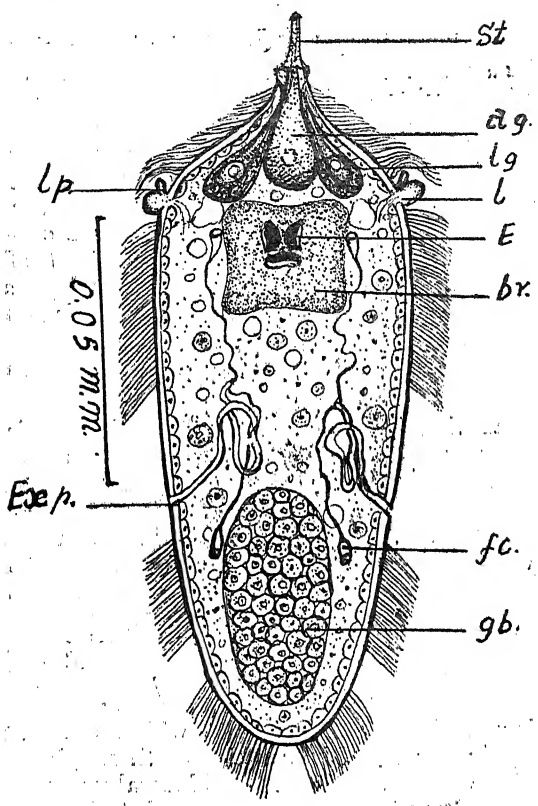

Fig. 2. Miracidium.

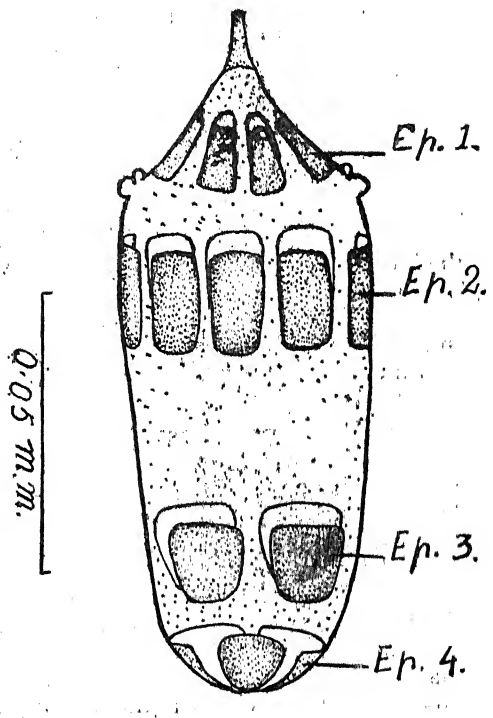

Fig. 3. Epidermal plates of the Miracidium.

The miracidium is usually pyriform in shape, broad anteriorly and narrow posteriorly. In life, it shows great flexibility and continuous peristaltic changes of form. It is able to swim rapidly by means of its cilia arising from the epidermal plates and in appearance and behaviour resemble ciliate protozoans. The body in ten specimens measures 0·13—0·16 mm. (av. 0·14 mm.) in length and 0·04—0·06 mm. (av. 0·06mm.) in breadth. They are positive to light and negative to gravity as these reactions bring about their escape from the bottom on which the capsules lie and also from the fact that they are always concentrated in large numbers in the side tube of the hatching flask devised by McMullen and Beaver (1945).

The number and arrangement of ciliated epidermal plates is similar to that found in the miracidium of *C. marginatum* and in general resembles those of Schistosomata and Strigeata. The first tier consists of six, the second of eight, the third of four and the fourth of three plates respectively from anterior to posterior end. A wide gap separates the second and third row of plates. The cilia covering each row of plates from the anterior to the posterior end range between 0·0138 mm. —0·018 mm. in length. The places between the plates without cilia represent the portions of the soft subepithelium lying below the epidermal plates. It is a continuous layer of small flattened cells round the body. Scattered spherical cells of various sizes with distinct nuclei are found in this layer and they may be analogous to the cells found in the miracidia of various groups *viz.* Shistosomes, striegids and spirorchids. They resemble the cells found in the miracidium of *C. marginatum.* In addition to these cells, refractory granules and small vacuoles are also present in the subepithelium.

The apical gland or primitive gut is sac like, filled with granules and extends back upto the anterior margin of the nerve mass. Hunter and Hunter (1935) while describing the miracidium of *C. marginatum* have called this structure as "apical gland" because they found granular contents resembling a secretion and no lumen in it. They have further written" Since the span of life of a miracidium is short (a gut, being, therefore, unnecessary) we cannot believe this structure functions as an intestine. This leads us to the opinion that the structure is a part of the penetration apparatus." The apical gland bears an apical papilla which carries a stylet about 0·018 mm. long. This may be withdrawn into the anterior part of the apical gland. The apical gland, the apical papilla and the stylet collectively form a suitable penetration organ for the miracidium to drill its way into the molluscs body.

On either side of the apical gland is a single penetration gland which opens at the base of the apical papilla through very fine ducts. The contents of these glands appear to be coarsely granular after staining with neutral red. The lateral processes and the lateral papillae characteristic of Strigeid, Schistosome and Spirorchid miracidia are also present in this species. However, these structures were not found to connect a vesicle and no drops of secretions exuding from them could ever be observed. They presumably seem to have sensory functions.

The most prominent structures to be readily visible are the three eye spots which are located in the median line over the brain mass at about 0·048 mm. from the anterior end. They are cupshaped and darkly pigmented and appear to have a lens like structure. The brain or nerve mass is located posterior to the apical gland and extends from the level of the lateral processes to the posterior margin of the second row of epidermal plates. It is slightly bilobed and roughly rectangular in outline. The brain or nerve mass has been described by several workers under different names. Price (1931), Cort, Ameel and Vander Woude (1953) call it as "central nerve mass." Faust (1949) refers the structure to be "posterior penetrating gland" and Chu and Cutress (1954) state that it is a sac like organ lacking characteristics of either a gland or a ganglion in schistosome miracidia.

The excretory system has two pairs of flame cells, one anterior and the other posterior. Each cell of the anterior pair is located anterolateral to the brain in level with the lateral processes. The cells of the posterior pair lie in the hinder region of the body in level with the posterior half of the third row of epidermal plates and anterolateral to the germ ball. Capillaries from flame cells unite to form a common collecting duct on either side which open through excretory pores located in the groove of the second and third tiers of epidermal plates.

The germ cells are concentrated in the form of a compact mass that is large oval and occupies the posterior fourth of body.

The miracidium differs in shape and certain features of its morphology from the miracidium of *C. complanatum* described by Yamaguti (1934) which is ciliated only at anterior and posterior ends. It appears slightly larger in size from that of *C. marginatum* and also differs in other details such as the size of the germ ball and the number of penetration glands. The miracidium of *C. marginatum* has three penetration glands on either side of the primitive gut where as the present species has a single pair of these glands.

Sporocyst and Rediae Generations :

(Figs. 4, 5 & 6)

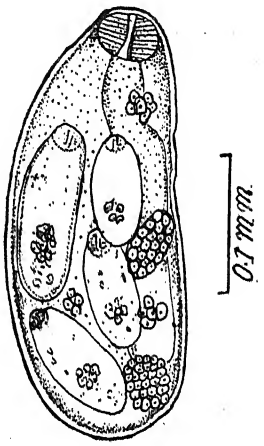

Fig. 5. Mother redia with daughter embryos and germ cells.

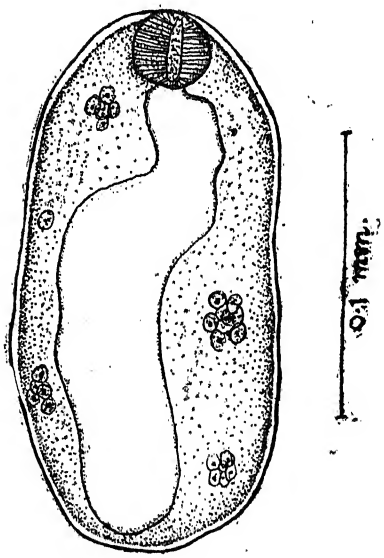

Fig. 4. Young Mother redia with germ cells.

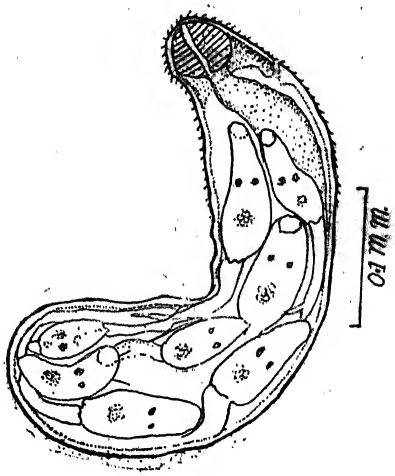

Fig. 6. Daughter redia with mature cercaria.

Lymnaea luteola exposed to miracidia on 31st August, 1955 became positive for asexual generations after 12 days. A snail taken out from the lot and when examined had mother rediae attached to the intestinal wall and also in the liver. The sporocyst stage was not recovered. Young mother rediae 12 days old are oval, sac like and measure 0·1 - 0·18 mm. in length and 0·04 - 0·045 mm. in breadth. Mother rediae 20 days old recovered from the digestive gland of another snail are large and recognizable from the daughters in having large wide gut almost reaching the posterior end and few germ cells scattered in groups of 3-5 on sides of the gut. These measure 0·12 - 0·18 mm. in length and 0·045 - 0·069 mm. in breadth. The pharynx measures 0·021 - 0·03 mm. in diameter. Mature mother rediae containing germ balls 5-8 in number stained and mounted measure 0·308 - 0·42 mm. in length and 0·11 - 0·21 mm. in breadth. The pharynx measures 0·024 - 0·056 mm. in length and 0·03 - 0·06 mm. in breadth.

In another snail opened one month after exposure to miracidia contained daughter rediae with germ balls varying from 7-14 in number. These measured 0·23 - 0·39 mm. in length and 0·024 - 0·045 mm. in breadth. Fixed and stained specimens of daughter rediae having cercariae in them measured 0·392 - 0·492 mm. in length and 0·098 - 0·141 mm. in breadth. The pharynx measured 0·03 - 0·033 mm. in diameter. The second generation of rediae infecting the liver of snails are distinguised from the first generation of rediae (mothers) in having spines covering the anterior third of body, mass of developing cercariae and a birth pore near the anterior end lateral and posterior to the pharynx.

Cort and his coworkers (1951) recognize three generations of rediae in the life history of *C. marginatum i. e.* a single redia produced by the sporocyst, redia producing rediae that develop in it and cercaria producing rediae found in mature infections. During the present investigations, rediae producing rediae in it and the rediae producing cercariae in it were studied but the sporocyst conta ining a single rediae in it was missed in every experiment and the author likes to revise the experiments and describe this stage in detail in due course. The daughter rediae produce cercariae within 35-40 days which leave the snail host and lead a free life in water, for a short time.

The Cercaria : (Figs. 7 & 8)

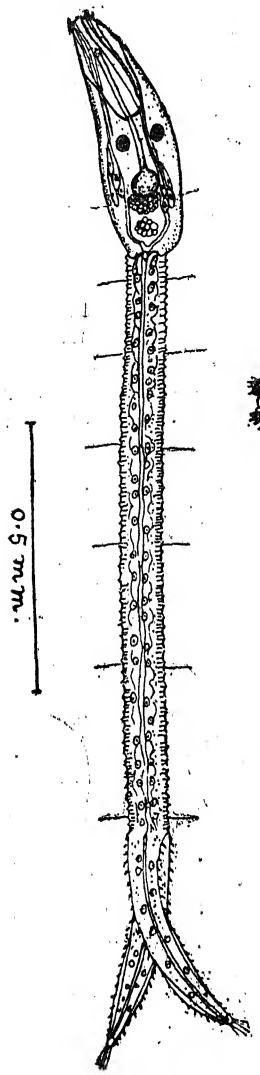

Fig. 7. Cercaria entire.

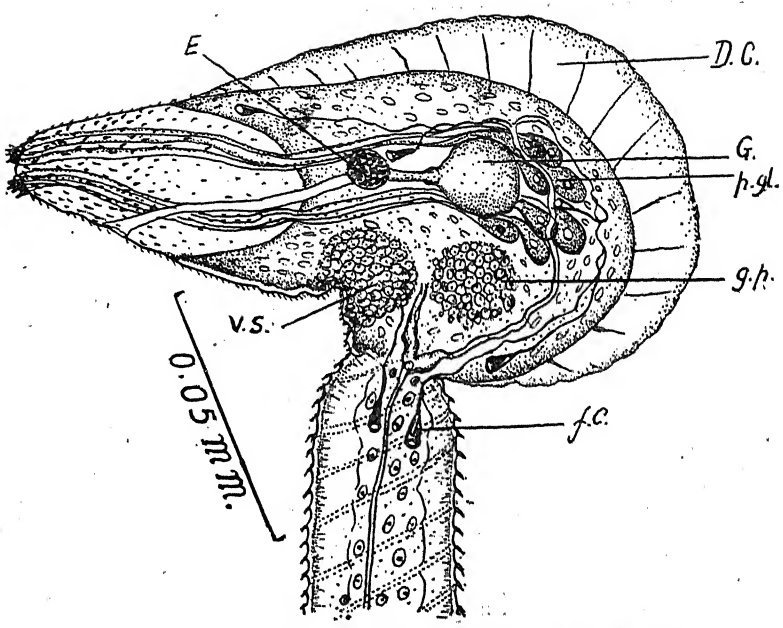

Fig. 8. Cercaria showing details of body structure, Lateral view.

The cercariae of *C. piscidium* resemble those of *C. marginatum* in their general appearance and behaviour. After leaving the snail, the larvae suspend themselves in water with the body hanging down, tailstem turned upward in a straight line and furcae held relatively together. The body is curved ventrad so that the anterior organ takes a position close to the base of the tailstem. Whem the water is disturbed, the larvae are stimulated to activity and regain their original position by lashing movement of the tail and propelling actions of the furcae. The cercariae are short lived, delicate and disintegrate very soon after mounting preparations are made.

The body 0·08 – 0·104 mm. (av. 0·095 mm.) long and 0·044 – 0·045 mm. (av. 0·04 mm.) broad is elongated, pearshaped narrow anteriorly, broad and massive posteriorly by convex dorsally and concave ventrally in lateral mounts. The anterior part of body is covered with thick backwardly pointing spines extending postrid for 1/3 to 1/4 the length of the penetration organ. The dorsal median finfold is delicate 6-7 u wide in living specimens and extends from the level of the eye spots upto the posterior end of body. When thrown into folds, its cuticular thickenings apparently giving the appearance of finrays become more distinct.

The eye spots are pigmented and measure 0·02 mm. in diameter. They lie at a distance of about 0·05 mm. from the extreme anterior end. They are crescentic in section with their concavities directed anterolaterally.

The tailstem is narrow than the body and measures 0·22 mm. – 0·26 mm. (av. 0·25 mm.) in length and 0·016 mm. – 0·028 mm. (av. 0·021 mm.) in breadth in ten specimens. The furcae are 0·072 mm. – 0·08 mm. (av. 0·07 mm.) long provided with spines. The spines on the tailstem are curved at their tips as in schistosome cercariae and long filamentus hairs are present as in strigeid cercariae.

The penetration organ is long, narrow and measures 0·04 mm. – 0·044 mm. (av. 0·036 mm.) in length and 0·016 mm. – 0·02 mm. (av 0·013 mm.) in breadth. The mouth is median, ventral and slightly posteriad to the middle of penetration organ. It leads into a long conspicuous gut apparently without any muscular pharynx and ends in a sac like undivided caecum behind the eye spots. The primordium of acetabulum is present in the form of a mass of cells somewhat smaller than the penetration organ and exposed at the ventral surface of body slightly dorsal to the primordium of acetabulum.

The penetration glands are small, in four pairs and located around the caecum. Their fine ducts open at the extreme tip of the anterior penetration organ and are capped with hollow piercing spines as in schistosomes. The excretory bladder is V shaped and located at the posterior end of body. The two arms of the bladder receive an anterior and a posterior collecting duct on either side. Two pair of flame cells are connected with the anterior tubules and three pairs to the posterior tubules, two in the body and one in the tail giving a total of eight flame cells in the body and two in the tail. The caudal excretory canal runs through the middle of the tailstem and bifurcates at the furca. Each furca contains the extension of the caudal excretoy canal wnich opens at the tip throught bladder like enlargements amongst group of large spines.

The cercaria resembles closely *C. bombayensis* no. 8 Soparkar, 1921 ; *C. brevifurca* McCoy, 1929 ; *C. whitentoni* Croft, 1921 ; *C. (Clinostome) hunterii* Singh, 1952 in many respects. From *C. bombayensis* no. 8, it differs in the absence of a head gland, *C. whitentoni* is similar to the cercaria of *C. marginatum* and may be indentical with that as both contain four pairs of peneration glands and five pairs of flame cells. From these two forms, the present species differs in having hollow conical spines capping the ducts of penetration glands, numerous spines in the antetior region and in the absence of a pharyngeal bulb. C. *brevifurca* has no flame cells in the tail which appears to be doubtful and in this respect differs from the new species. *Cercaria (Clinostome) hunterii* has four penetration glands and the number of flame cells is eight whereas the present species has four pairs of penetration glands and five pairs of flame cells.

The Metacercaria : (Figs. 9 & 10)

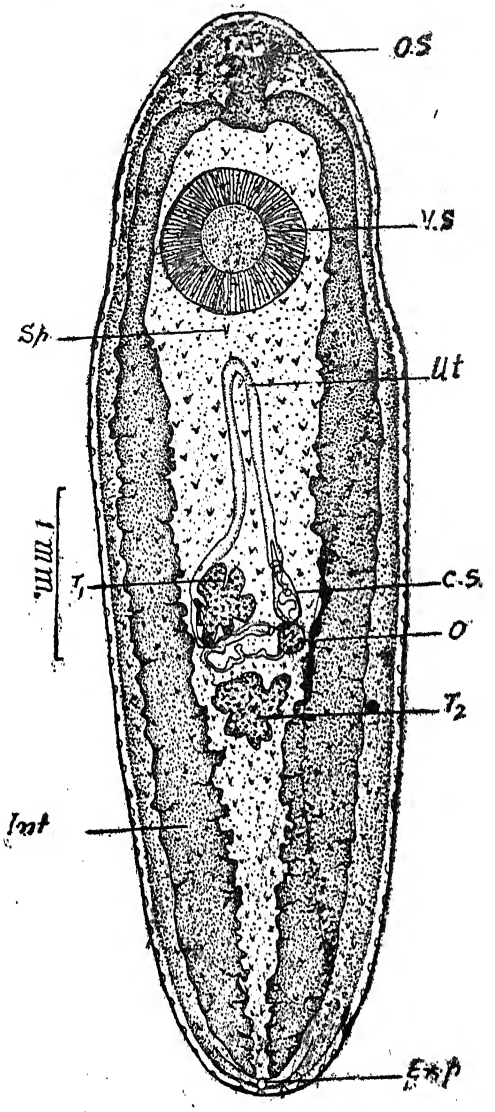

Fig. 9. Metacercaria, Dorsal view.

The metacercariae are nonencysted and move freely in the body cavity of the piscine hosts. In heavy infections the worms are generally found aggregated near the posterior region of the body cavity. A single host may have from 5—250 or more worms attached almost to every organ in the body cavity.

The larvae are yellowish white in colour, relatively small, thin and more slender than the adult worms. They perform active movements of contraction and elongation while alive. The body in permanent mounts measure : 3·31—3·42 mm. (av. 3·8 mm) in length and 0·975—1·3 mm. (av. 1·16 mm.) in breadth in ten

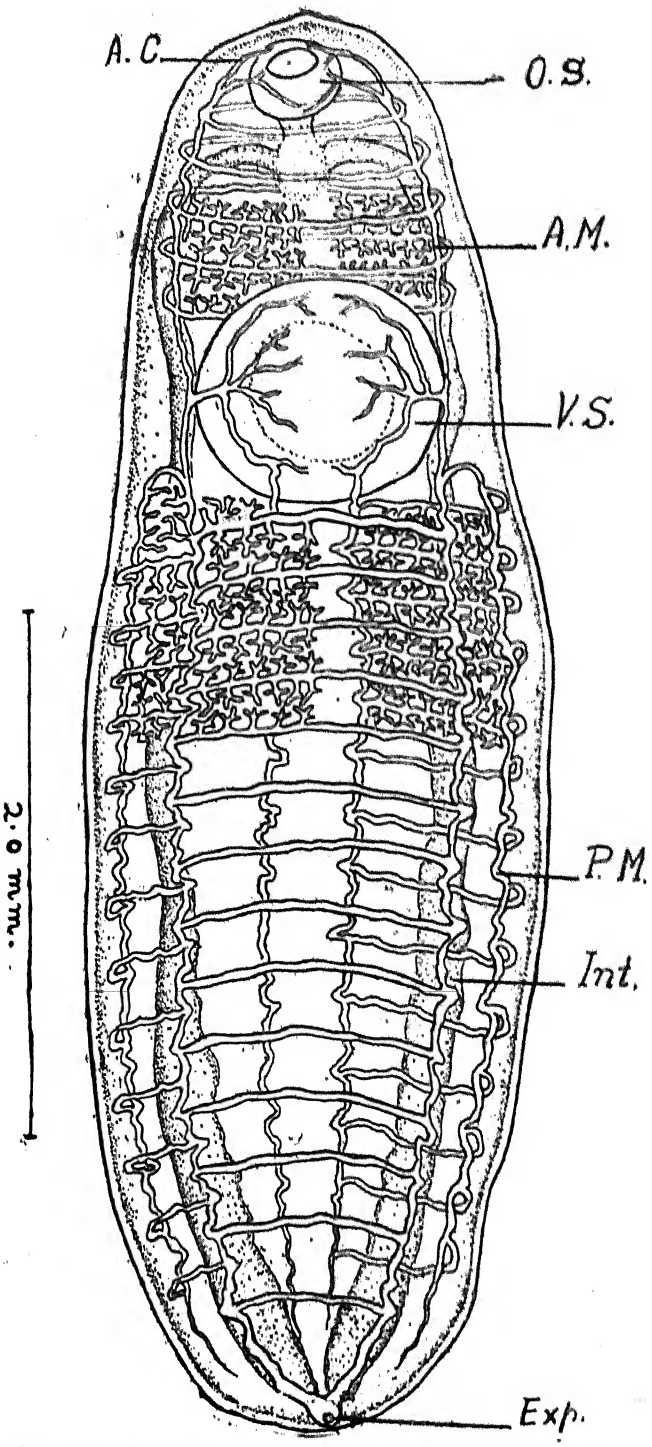

Fig. 10. Metacercaria, showing principal vessels and a portion of a complex network of excretory system.

specimens. There is very slight flexture at the level of the acetabulum to give a truncated appearance to the anterior part of body as in the adults. The entire body surface is beset with numerous prominent spines directed posteriorly. The spines are broader at the base and more conspicuous than in the adults. The musculature is well developed but the worms look thin and transparent. The oral field is less conspicuous than in the adults. The oral sucker is subterminal smaller than the acetabulum and measuaes 0·13 mm.—0·19 mm. (av. 0·14 mm.) in length and 0·156—0·286 mm. (av. 0·198 mm.) in breadth. The ventral sucker situated at a distance of 0·312 mm.—0·481 mm. from the oral sucker measures 0·42 mm.—0·75 mm. (av. 0·54 mm) in length and 0·42 mm. — 0·71 (av. 0·52 mm.) in breadth.

The mouth leads into a small prepharynx and a slight saccular dialation which gives the impression of pharynx with delicate and inconspicuous musculature. This structure has been referred to as a "*Pharyngeal Bulb*" in *Clinostomum complanatum* by Yamaguti (1934) and its absence in the adults is a peculiar character of Clinostomes. The intestinal caeca originate just at the base of the pharyngeal bulb and behind the acetabulum they become much wide so as to occupy larger part of body on either side. Small lateral diverticula characteristic of the genus are present. The caeca are filled with fine granular contents which give an yellow colour in the living specimens.

The excretory system consists of a V shaped bladder located at the posterior end. The main collecting ducts and the flame cells could not be traced due to the presence of a complex subcutaneous network of large and small vessels containing a transparent fluid filled with granules of nearly uniform size. At intervals some of the fluid with the granular content was found to discharge from the excretory pore. The system resembles in many respects the reserve excretory system of Strigeid metacercariae specially the type present in *Neascus* metacercariae (Hughes, 1927) and is also present in other Clinostome metacercariae studied by me. No doubt, the system also resembles the lymph system of many trematodes and has an uniform pattern but is lost in the adults. As such, for the sake of convenience, I have considered this system as a reserve excretory system until more is known about its origin and development in Clinostomes. The pattern of the reserve excretory system is shown in fig. 10. The two arms of the bladder receive two main longitudinal trunks which are joined by two commissural vessels ramifying over the two suckers. From the posterior commissural vessel, two longitudinal trunks arise and proceed backwards ventrally in between the arms of the bladder. The two trunks and the main longitudinal trunks are joined dorsally and ventrally by small commissures which send many small diverticula to fill in the gaps ultimately giving the appearance of a network. At the level of the ventral sucker arise on either side a marginal vessel proceeding backwards. Small transverse connection join these marginal vessels with the two median vessels on the ventral side and dorsally with the main longitudinal trunks.

The reproductive organs though fully represented in mature metacercariae are, however, in a primary stage and their differentiation and other changes take place only after a metacercaria has entered the definitive host. The testes have finger like processes and the uterus has a cellular coating along its entire length. The cirrus is inserted into the metraterm. The ovary is small and the vitellaria undifferentiated.

The Adult: (Fig. 11)

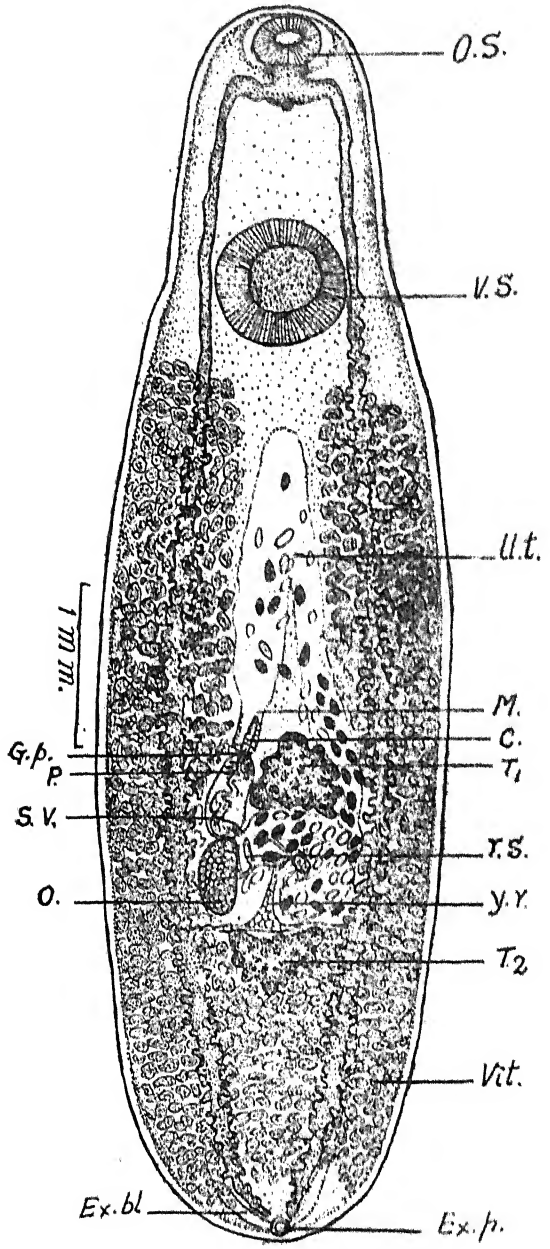

Fig. 11. Adult, ventral view.

Sexually mature worms obtained from natural as well as artificial infections are similar and measure slightly larger than the metacercariae. The increase in size of the worms mainly results from the expansion of the posterior half of body due to the development of the gonads and the uterus which is literally packed with

large number of eggs. The cuticle is thin and beset with spines. The muscular layers are well developed. The worms measure: 3·8—6·8 mm. (av. 6·44 mm.) in length and 1·9—2·65 mm. (av. 2·28 mm.) in maximum breadth. The mouth is subterminal and the oral sucker measures 0·24—0·48 mm. × 0·272—0·32 mm. in size. A pharynx is absent and the oesophagus is very short. The intestinal caeca are narrow, dark and have many small diverticulae on both the sides. They terminate a little infront of the posterior end of the body and are mostly enveloped by the vitelline follicles. The acetabulum is situated at a distance of 0·432—0·82 mm. from the oral sucker and measures 0·672 - 0·96 mm. × 0·64—1·04 in size.

The reserve bladder of the metacercaria is lost in the adult, the excretory pore retains its subterminal position at the posterior end but the arms of the bladder are overshadowed by the crowding of vitellaria and connot be traced anteriorly.

The genital pore lies smubedianally on the right side at about the level of the anterior margin of anterior testis. The testes are large, irregularly lobed and lie centrally one behind the other at the posterior half of body. The anterior testis measures 0·56 - 0·96 mm. × 0·72 - 1·2 mm. and may have 4-5 lobes. The posterior testis is Y shaped and measures 0·48 - 0·88 mm. × 0·8 - 1·04 mm. The vasd efferens from each testis unite to form a very small vasdeferens behind the cirrus sac. Special efforts were made to determine whether this species has a vesicula seminalis externa as described earlier by Southwell and Prashad (1918). A detailed study of serial sections revealed that a vesicula seminalis externa is absent. The cirrus sac is small and measures 0·45 - 0·48 mm. in length and 0·16 - 0·32 mm. in breadth. It lies on the right side in between the anterior testis and the intestinal caecum and extends from the genital pore to the anterior face of the ovary. The coiled vesicula seminalis occupying more than half the space inside the cirrus sac is filled with sperms. A parsprostatica is present and the cirrus is slightly muscular, tuberculate and inserted into the metraterm in many individuals. Baer (1933) and Bhalearao (1942) have not mentioned the presence of a parsprostatica in Clinostomes. The ovary is small, subspherical or beanshaped and lies on the right side near the right caecum. It measures 0·27 - 0·4 mm. × 0·19 - 0·32 mm. The oviduct is long, thin and winds about considerably in the intertesticular space. At a short distance from its origin, it gives a small receptacutaculum seminis and a short Laurer's canal. The shell gland mass is nearer the median line. The vitelline glands are small, extend in the intercaecal area behind the ventral sucker and in many specimens they meet in the median line above the terminal part of the uterus and below the ventral sucker. Distally, they occupy the entire space behind the posterior testis and do not extend upto the the ends of intestinal caeca. The transverse vitelline ducts running at the anterior face of the posterior testis unite to form a prominent yolk reservoir near the median line. A duct from the reservoir meets the shell gland mass. The uteroduct occupies the intertesticular area and thereafter curves round on the left side of the anterior testis to end in the uterus. The uterus passes anteriorly in the median line to a distance of 0·042—0·14 mm. from the posterior margin of the acetabulum. The terminal part of the uterus forms the metraterm which appears to be lined by cuticle and opens into the genital atrium. The uterine eggs measure 0·084 - 0·09 mm. × 0·048 - 0·054 mm.

Comparison :

Clinostomum piscidium differs from *C. foliiforme* Braun, *C. complanatum* Braun, and *C. attenuatum* Cort. in many respects specially in being small, in the position of

gonads, genital pore and the extension of vitellaria. It differs from *C. detruncatum* Braun and *C. foliiforme* Braun in several characters. The former has uterine stem with lateral branches and in the latter the vitelline follicles extend anterior to the ventral sucker. *C. lophophallum* Baer has vitelline follicles extending upto the equator of the ventral sucker and is larger than the present species. *C. heluans* Braun differs from *C. piscidium* in having the genital pore in zone of the anterior testis and the gonades in the extreme posterior portion of the body. *C. intermedialis* (Lamont) differs from *C. piscidium* in having a larger size and the ascending limb of the uterus being very long. *C. phalacrocoracis* Dubois and *C. chrysicthys* Dubois have genital aperture located posterior to the anterior testis and at the level of the caudal margin of the anterior testis respectively. *Clinoctomum pscudoheterostomum* Tubangui and *C. dalagi* Tubangui as well as *C. dictyotum* Monticelli differ from the present form in several respects. The worms resemble *C. dasi*, *C. gideoni* and *C. prashadi* (all of Bhalerao, 1942) in size but differ in other respects particularly in the position of the gonads.

DISCUSSION

The life history of *Clinostomum piscidium* Southwell and Prashad, 1918 has been studied from experimental infections in the laboratory and various stages described. Further information on the morphology of the worm both in the metacercaria and adult stage has been added.

The morphological details of the egg and the miracidium of *C. piscidium* show general resemblance to those of *C. marginatum*, the only species whose life cycle has been studied so far in detail. The miracidium in its fundamental organization and behaviour also resembles those of Strigeid and Schistosome miracidia. The various structural details such as the shape and size of body, number and position of penetration glands, branching of excretory tubules, number of flame cells and the shape and size of the stylet the nature of eye spots, the character of the germinal mass and the number and arrangement of epidermal plates show great conservativeness and may be regarded more important characters for showing group relationship in addition to their being valuable criteria for specific diagnosis.

The intramolluscan phase of the life cycle of the present species is essentially the same as that of *Clinostomum marginatum* and covers a period of 35-40 days. The mother rediae produced by the sporocyst have germ cells scattered in groups of 3-5. The older mother rediae have both daughter redial embryos and germ cells in them. The daughter rediae contain groups of germinal cells and developing cercariae. The mechanism for the multiplication of the germinal cells in the rediae of the two generations is such that large number of embryos are produced and in the last generation of rediae the multiplicatian of germ cells produces large number of cercariae which emerge from the snail hosts and are infective to the fish hosts.

The cercariae of *C. piscidium* possess a rhabdocoel gut, rudimentary ventral sucker, five pairs of flame cells, and develop in rediae like the cercaria of *C. marginatum*. In general, they resemble *C. bombayensis* no. 8 Soparkar, 1921; *C. brevifurca* McCoy, 1929; *C. whitentoni* Croft, 1934 and *C. (Clinostome) hunterii* Singh, 1952 all included in the "Clinostome Group" by the author in 1952. The Clinostome cercariae appear to occupy an unique position among the furcocercous cercariae on account of their being lophocercous brevifurcate, pharyngeal or apharyngeal, pigmented and their development in rediae instead of sporocysts. They possess long filamentus hairs and spines on the tail and the furcae are without finfolds. The excretory bladder is V shaped and the acetabulum represented by a

mass of cells somewhat smaller than the anterior penetration organ. They have many features in common with schistosome and strigeid cercariae on one hand and with Spirorchid Cercariae (Wall, 1941) and Lophocercariae (Cercariae of blood flukes of fishes; Aporocotylid and Sanguinicolid cercariae) on the other hand.

The clinostome cercariae resemble the lophocercous monostomes (Aporocotylid and Sanguinicolid cercariae) in their general appearance, in having a dorsal body crest and no true acetabulum. However, they differ from them in having flame cells in the tail and in their development in rediae instead of sporocysts. The spirorchid cercariae have no pharynx, acetabulum is well developed, the penetration glands are characteristic and are both acidophilic and basophilic and the gut is forked. They have also pigmented eye spots, furcal finfolds and a dorsal body crest and flame cells in the tail. Mehra (1950) considers that the Clinostomata having brevifurcate pharyngeal cercariae connect the apharyngeal schistosomata with the pharyngeal strigeata and that they are also closely related to the Brachylaemata. He has discussed at length the resemblances in the life history of Clinostomes to Strigeatoidea with particular reference to the structure and mode of development of various stages in the life history of Clinostomes. Tracing genetic relationships among the groups of trematodes mainly on the basis of researches of Hunters (1934, 35), Krull (1934), La Rue (1926,33) and Allison (1943) he created the suborder Brachylaemata under the order Strigeatoidea La Rue, 1926.

The inclusion of the suborder Clinostomata Allison, 1943 in the Order Strigeatoidea La Rue, 1926 is further supported by the similarity of structure and nature of pharynx, acetabulum and excretory system in clinostome cercariae. According to Miller (1926) pharynx is an important character and its absence characterises the entire group of blood flukes either in cercariae or in the adults. It is present in Bucephalata, Strigeata, and Brachylaemata. As stated above, the Clinostome cercariae may or may not have a pharynx. *C. bombayensis* no. 8, *C. brevifurca* and *C. whitentoni* do not have a pharyngeal bulb, though it is found in *Cercaria C. marginatum* and *Cercaria (Clinostome) hunterii*. The Clinostome metacercariae on the other hand possess a pharyngeal bulb which is lost in the adults and signifies a close relationship to Strigeids and Schistosomes. The encystment or nonencystment also is a common character of Strigeid and Clinostome metacercariae. The pharynx, however, appears to be a transitory structure in the furcocerceus cercariae. Oiso (1927) recorded a muscular pharynx in the cercaria of *Bilharziella yokogwai* which is lost in the adults. The cercaria of *Apharyngostrigea pipientis* (Faust) has a pharynx but the adults are apharyngeal. Similarly *Cercaria multicellulata* the larval stage of *Posthodiplostomum minimum* (McCallum) wrongly placed in the pharyngeal group by Miller (1926) actually does not possess a pharynx though the adults have the pharynx.

As regards the ventral sucker, its presence or absence is also of no prime importance as already established by Stunkard (1934) who advanced the thesis that both distomes and monostomes are polyphyletic groups and that neither can be regarded as a simple primitive type. He further stated that certain distomes appear to be derived from monostomes whereas certain monostomes appear to be derived from distome ancestors. The ventral sucker in the form of a group of cells is not the only character of Clinostome cercariae but is also found in several Strigeid cercariae. *Cercaria bessiae* Cort and Brooks, 1928, the larval stage of *Crassiphiala amblopiitis* and *Cercaria multicellulata* and several other strigeid cercariae have ventral sucker in the form of a group of cells, and the true sucker appears during the development of metacercariae. Thus the presence and absence of ventral sucker and pharynx appears to be a common character of Strigeid and Clinostome cercariae.

The pattern of the excretory system is similar in Strigeidae, Clinostomatidae, Schistosomatidae and Bucephalidae as already pointed out by La Rue in 1926. During the present investigations, the observations on a reserve excretory system in the metacercariae of *C. piscidium* brings Clinostomes nearer to the Strigeidae and the Brachylaemidae as the metacercariae of these two groups also possess a reserve excretory system.

Thus the view that Clionstomes combine the characters of blood flukes and Strigeid trematodes is further supported by my present observations on the life history of *Clinostoum piscidium*.

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LETTERING TO FIGURES

A. C	Anterior commissural vessel	lg.	Lateral gland
A. M.	Anterior marginal vessel	lp.	Lateral papillae
a. g.	Apical gland		
br.	Brain Mass	M.	Metraterm
C.	Cirrus	O.	Ovary
C. S.	Cirrus sac	O. S.	Oralsucker
D. C.	Dorsal crest	P.	Parsprostatica
E.	Eyes.	pgl.	Penetration gland
Ep_1-Ep_4	Epidermal plates		
Ex. bl.	Excretory bladder	P. M.	Posterior Marginal vessel
f. c.	Flame cells		
G.	Gut.	r. s.	Receptaculum seminis.
gb.	Germ ball		
g. c.	Germ cell	Sp.	spine.
g. p.	Genital primordium	St.	Stylet
G. P.	Genital pore.	S. V.	Seminal Vesicle
Int.	Intestine.		
l.	Lateral process.	T_1-T_2	Testes.
		Ut.	Uterus
		Vit.	Vitellaria
		V. S.	Ventral Sucker
		Yr.	Yolk Reservoir

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STUDIES ON A NEW SPECIES OF THE GENUS *EUROSTOMUM* (TREMATODA : OPISTHORCHIIDAE) FROM THE INTESTINE OF *MASTACEMBALUS ARMATUS* AND THE SYNONYMITY OF THE GENUS *GOMTIOTREMA* GUPTA, 1953 TO THE GENUS *EUROSTOMUM* MACCALLUM 1921

By

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[Received on 14th November 1958]

INTRODUCTION

In this communication a new species of the genus *Eurostomum* viz., *E. armati* n. sp. has been described. The distomes were obtained from the intestine of fresh water fish *Mastacembalus armatus*. The work was carried out in the department of Zoology, College, of Science, Raipur.

Eurostomum armati, n. sp.

The worms are dorsoventrally flattened with rounded anterior and posterior ends measuring 2.36-5.6 mm. in length and 0.57-1.4 mm. in maximum breadth in front of the ventral sucker.

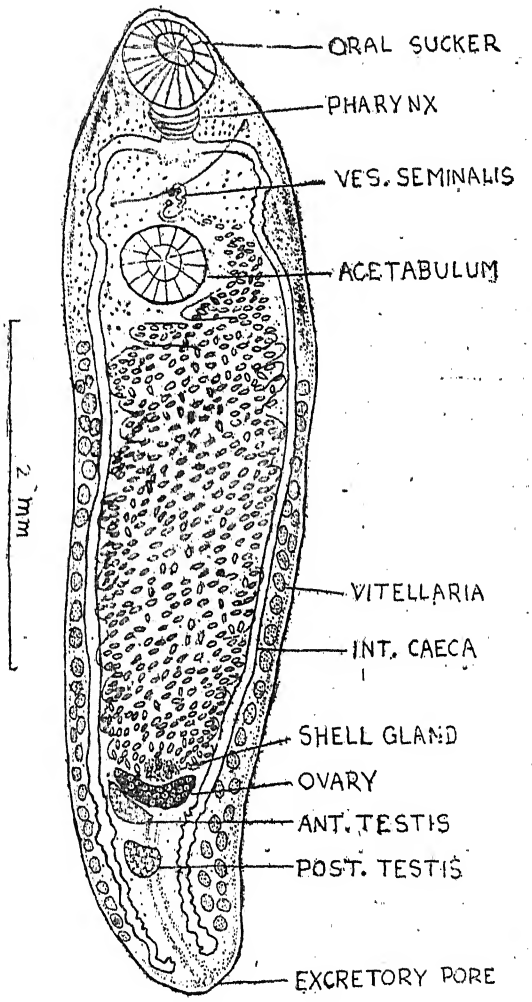
The oral sucker is subterminal in position and measures 0.35—0.53 × 0.35—0.56 mm. in diameter. The ventral sucker, slightly smaller than the oral sucker measures 0.3—0.5 × 0.3—0.53 mm. in diameter and is placed at a distance of 0.76—1.26 mm. from the anterior end. The prepharynx is absent. The pharynx measures 0.05—0.12 × 0.12—0.15 mm. The oesophagus is very small. The intestinal caeca first diverge transversely and then proceed backwards terminating a little in front of the posterior end of the body and have crenated margins at the commencement and at the posterior end behind the ovary.

The subterminal excretory pore leads into a Y-shaped bladder with the median stem extending upto the ovary.

The two testes lie near the posterior end of the body. They have smooth outlines and are obliquely placed one behind the other. Their shape varies from oval to semilunar, the anterior testis generally taking semilunar shape in more mature specimens. The anterior testis measures 0.1—0.14 × 0.15—0.24 mm. and the posterior testis measures 0.12—0.25 × 0.19—0.25 mm.

The cirrus sac is absent. The coiled vesicula seminalis, surrounded by a large number of prostate gland cells, lying in front of the acetabulum, leads into a small pars prostatica which ends in the muscular cirrus. The male genital pore is separate and is placed in front of the female genital pore in the median line. Both the genital pores lie in a common genital atrium.

The shape of the ovary varies from oval to semilunar. It lies in front of the anterior testis touching its anterior border and measurers 0.15—0.18×0.16—0,49 mm. In front of the ovary is situated the shell gland mass.



(Text fig. 1.) *Eurostomum armati* n. sp. Dorsal view.

The vitelline glands consist of round or oval follicles mostly extracaecal, but at places overlapping the caeca. They extend from behind the ventral sucker to the hind end of intestinal caeca. The glands do not extend symmetrically on both sides of the body. The uterus occupies the intercaecal space between the ovary and the ventral sucker.

The eggs are oval and measure 0·03—0.05 × 0.04—0.06 mm.

DISCUSSION

There is only one species of the genus *Eurostomum*, *E. micropteri* Mac Callum, 1921 reported so far. *E. armati*, n. sp. differs from *E. micropteri* in having oral sucker only slightly larger than the ventral sucker, the vitellaria extending poste riorly almost upto the hind end of the intestinal caeca, the caeca do not form M at their commencement and the male and female genital pores are separate.

The genus *Gomtiotrema* Gupta, 1953, has striking similarity with the genus *Eurostomum*. The only difference seen in *Gomtiotrema* from *Eurostomum* is the presence of oesoph ageal pouches in it. Structures similar to those called as oesophageal pouches in *Gomtiotrema* are also seen in *Eurostomum*. Hence the genus *Gomtiotrema* is synonymous to *Eurostomum*. Thus the genus *Eurostomum* includes only three species :

Genotype : *E. micropteri*. Mac Callum, 1921 in
Micropterus salmoides; New York Aquarium.
E. attu(Gupta, 1953) (*Syn. Gomtiotrema a. G*) in
Wallagonia attu; India.
E. armati n. sp. in
Mastacembalus armatus; India.

Key to the species of the genus *Eurostomum* MacCallum, 1921, (Species of the synonymous genus included)

1. Caeca recurved and M-shaped at commencement ... *E. micropteri.*

   Caeca extend transversely at commencement .....2.

2. Oral sucker larger than the ventral sucker, ventral sucker at anterior fifth of body region, vitellaria extend from much behind ventral sucker...*E. attu*

3. Oral sucker approximately equal to ventral sucker, ventral sucker at anterior third of body region, vitellaria extend from posterior level of acetabulum ..... *E.armati*

ACKNOWLEDGEMENTS

The author is grateful to Dr. R. N. Singh, Reader in Zoology, College of Science, Raipur for his keen interest and guidance in this work. Thanks are also due to Principal, Dr. K. Singh, College of Science, Raipur for providing necessary facilities. I am thankful to Shri J. N. Saxena, Lecturer in Zoology, College of Science, Raipur for help in many ways.

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DITRICHUM FLEXICAULE (SCHLEICH) HAMPE FROM INDIA

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[Received on 10th December 1958]

Ditrichum flexicaule has been reported from Britain where it invariably occurs without fruit (Watson, 1955). But in India, the species grows in thick clusters on soil in Garhwal region and fruits abundantly during March-April.

At maturity the plant appears dark coloured. Stem is from 3 cm to 5 cm high and is branched. Arrangement of leaves is not distichous. The base of the stem and subterranean portion bear rhizoids. Young ones are hyaline, smooth walled, tubular and branched but old ones are brownish black and considerably thick. Septa are frequently present in old ones particularly at places where branches arise.

Leaf is nearly 6 mm long. It is distinguishable into a short basal region that sudddenly narrows and tapers to a very long fine point. Mid nerve is broad and measures 145μ at base. It stops a little below the apex of the leaf. The hyaline and finely toothed apex is composed of elongated slender cells. Other cells of the upper region of leaf are short, sqarrish to rectangular measuring nearly 13·0μ $\times$ 8·5μ. Oval cells in this region are however, not wanting. Cells of the margin are thick and sqarrish to rectangular. The latter unlike others are generally broader than long. At base of leaf, cells are very long, narrow and rectangular measuring upto 98μ $\times$ 8·0μ.

Seta and capsule together measure 2 - 2·5 cm long. Seta is curved and the foot swollen. Calyptra has a relatively long beak. Its outer surface is black. Capsule is smooth, nearly 3·5 mm long and less than 1 mm broad. Operculum is small with a relatively long and curved hyaline beak measuring nearly 1 mm. Peristome consists of 16 teeth. Each is linear, filiform and bifurcated upto base. The upper half of each tooth is hyaline while the lower half is brown and transversly striated. Often the splitting of the sister segments is not complete. They may remain united at the base by the transverse bars. Sometimes, even two adjacent teeth may also be united by the transverse bar. All the segments converge upward to close the opening. Overwhelmingly large number of pale yellowish peg like papillae are present all over the surface of peristome teeth.

The most peculiar are the spores which are considerably large measuring from 40μ to 50μ. Each has a distinct exine and intine. The former is many sided and on some facets, papilae are present.

ACKNOWLEDGEMENT

Thanks are due to Dr. A. B. Gupta, M. Sc., Ph. D. (Edin.) with whom the author had been in the Garhwal area as a member of the Natural History Expedition.

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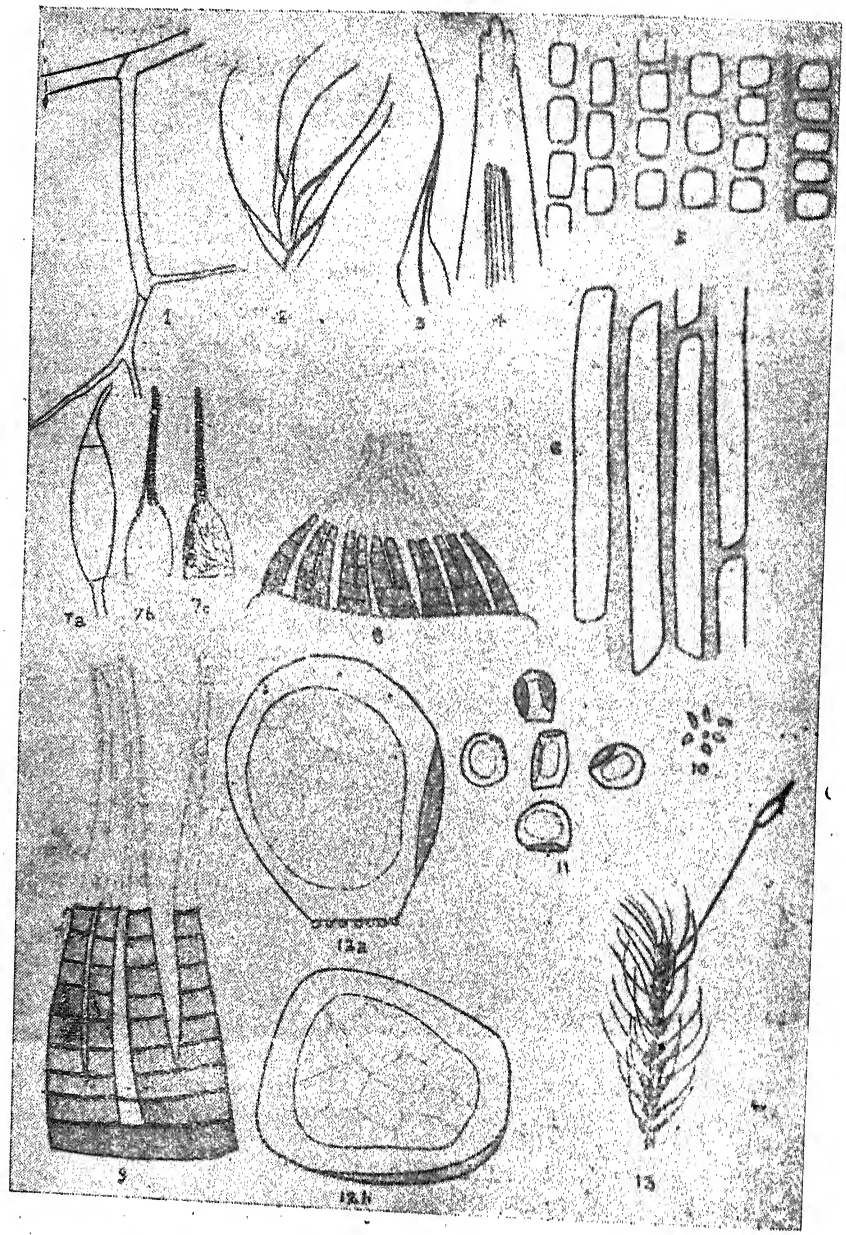

Fig. I — 1. Rhizoids ; 2. A portion of the plant (x6) ; 3. A leaf (x6); 4. Leaf tip (x120) ; 5. Leaf cells from middle (x480); 6. Leaf cells from base (x480); 7a. Capsule (x8) ; b and c Calyptra, inner and outer surface ; 8. Peristome teeth after remo ving the operculum (x50); 9. Peristome teeth (x480); 10 Papillae (x480) ; 11. Spores (x120) ; 12 a and b. Spores (x480) ; and 13. A portion of plant with sporophyte.

A NOTE ON THE VARIATIONS IN THE NUMBER AND DISTRIBUTION OF THE GENITAL PAPILLAE IN THE COMMON INDIAN EARTHWORM

(Pheretima posthuma, L. Vaill)

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[Received on 9th January 1959]

INTRODUCTION

Quite a few authors have reported anomalies with respect to the number and position of the genital papillae in the earthworms including several species of *Pheretima* (Stephenson 1930). Gates (1926) enumerated and tabulated a number of cases of variations (absence, multiplication and shifting) in the copulatory papillae in *Pheretima posthuma* (L. Vaill).

The present authors came across similar abnormal specimens of *Pheretima posthuma* while conducting practical classes in the past over two years. The number of such specimens examined was 77, and these were kept aside and later analysed. It was observed that there were a number of abnormal forms which were not included in Gates' tables. Those abnormal cases are being reported here as a supplement to the data given by Gates. The classification of these forms is based on the system used by the previous author.

OBSERVATIONS

Group A

This includes those cases where genital papillae are lacking on some or all of the usual positions.

Papillae lacking on segments	*Number of specimens*
(i) Left XVII	8
(ii) Right & Left XVII	1
(iii) Left XVII & Right XIX	1
(iv) Right XVII & Left XIX	1
(v) Right XVII & Right XIX	1
(vi) Left XIX (papilla abortive on right XIX & setal ring broken slightly at this place	1

Group B

This includes those cases where some of the usual papillae are absent on XVII and XIX while some additional ones are present on other segments.

Papillae lacking on segments	*Additional present on segments*	*Number of specimens*
(i) Right XVII ...	Right & Left XX ...	3
(ii) Right & Left XVII ...	Right & Left XX	
	Right & Left XXI ...	1
(iii) Right & Left XVII ...	Left XX ...	1
(iv) Left XVII & Right XIX ...	Right XV, Right XVI & Left XX ...	1
(v) Right & Left XVII & Left XIX ...	Right XVI, Right & Left XX & Left XXI ...	1
(vi) Right & Left XVII & Right XIX ...	Right & Left XX ...	1
(vii) Right XIX ...	Right XVI ...	8
(viii) Right XIX ...	Right XVI & Left XX ...	1
(ix) Right XIX ...	Right XV & Right XVI ...	2
(x) Left XIX ...	Left XV & Left XVI ...	1

Group C

This includes those cases where usual papillae are present on XVII & XIX and extra papillae present on other segments.

	Additional papillae present on segments	*Number of specimens*
(i)	Left XV & Left XVI	1
(ii)	Left XVI & Left XXI	1
(iii)	Left XX & Left XXI	1
(iv)	Right & Left XX and Left XXI ...	1

(*Note* :—In tables above right or left previous to the number of a segment means that a papilla was present or lacking on that side of the segment, presence or absence being indicated by the column.)

CONCLUSION

It is obvious from the data given by Gates and in the present note that among the abnormal individual any one, two, three or all the usual papillae may be absent on the 17th and 19th segments. Additional papillae generally occur on the 16th &20th Segments, in various combinations with the usual papillae. They occur less frequently on the 21st segment and still less frequently on the 15th and from 22nd to 27th segments.

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ON THE LIFE-HISTORY OF EPILACHNA CHRYSOMELINA ORIENTALIS ZIMM.*

By

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(Received on 1st. February 1958)

CONTENTS

INTRODUCTION

This paper deals with the biology of *Epilachna chrysomelina (F.) Subsp. orientalis* Zimm. In Agra the adult of this species is found during July and August and again in March and April. Biologies of different species of *Coccinella* have been studied by different authors but the literature on the biology of *Epilachna* is meagre. Lefroy (1909) gave brief notes on their biology. Hawkes (1920) recorded the average number of eggs laid to be 140 to 148 with a maximum of 418 in *Adalia bipunctata* and an average of 20 days spent as larva. Ayyar (1940) has also described *E. 12-punctata* and *E. 28-punctata* as pests. Kapur (1942, 1943) dealt with some of the Coccinellids, predaceous on aphids. The life-history and bionomics of two predaceous and one mycophagous species of Coccinellidae are dealt by Bagal and Trehan (1945). Kapur (1951) has given a short description of the four different instars of the larvae of *Epilachna*. Kapur (1951) and Koyama and Fukushima (1953) have dealt with the larval instars. Little attention has been paid to describe the general biology. Biology was first studied in the laboratory and later compared with observations in the field.

MATERIAL AND METHOD

The insects were collected from the fields at Mahu, Agra, in the months of February and March, 1957. They were kept in single pairs in petri-dishes ($4'' \times \frac{1}{2}''$) covered by muslin, and were fed with fresh leaves of the food plant twice daily at 7 a. m. and 2 p. m. Observations were made every 3 hours for eggs, moults and feeding from 7 a. m. to 7 p. m. The eggs obtained were removed to separate petri-dishes. The average maximum and minimum temperatures and humidity being 99·5°F. and 76·5°F. and 74% R. H. respectively.

*Contribution No. 77 from the School of Entomology St John's College, Agra.

Small potted plants were selected in the field and the leaves were enclosed in wire gauze cylinder open below. A pair of beetles were introduced in each of the wire-gauze cylinders. Observations were made at intervals of 3 hours from 7 a. m. to 7 p. m. every day. Average maximum and minimum temperature and humidity in the field being 103°F. and 79·5°F. and 77% R. H.

LIFE HISTORY

(i) *Copulation.* (Fig. 13)

The copulation is frequently observed during the day time. Usually the male beetle is seen touching the antenna of the female for a few minutes and then mounts on the back and applies its mouth parts to the tip of the abdomen and remains in position for 3 to 4 minutes. Later the female extends its ovipositor which is seen directed upwards. The male then turns its face and becomes parallel over the female intimately connecting the tips of the abdomen. The copulation is never observed during the night. Copulation lasts from 45 minutes to 3 hours. Oviposition starts about 7 days later.

(ii) *Oviposition.*

The eggs are invariably obtained sticking to the undersurface of the leaves laid one after another but never one over another. At the start of oviposition on the lst day a batch of 31 to 52 eggs are laid and stick well on the surface.

On the following days during successive oviposition one to six eggs are laid irregularly at any site. Females which are not provided with males lay scattered eggs. They do not hatch but dry up. Freshly laid eggs are easy to separate out from the leaf but after few hours all the eggs stick firmly to the surface and becomes difficult to detach. No egg is however laid after the 7th day. The famale then becomes very sluggish and eventually dies. Average number of eggs laid per female being 44.

(iii) *The egg.* (Figs. 1 and 2)

Freshly laid egg is clear white and barrel-shaped. They are very delicate. The anterior end is somewhat rounded and the posterier end is pointed. The egg is 1·0 mm. to 1·3 mm. long and 0·3 mm. to 0·5 mm. thick (An average of 12 being 1·1 mm. by 0·4 mm.). On the 2nd day they turn dirty yellow, with a dull smooth surface. The size remains the same.

On the fourth day the colour becomes somewhat deeper and the egg masses are seen more compact. The size of the egg is now 1·1 mm. to 1·5 mm. in length and 0·4 mm. to 0·5 mm. in width (an average of 12 being 1·2 mm. by 0·5 mm.). On the 7th day the colour is still deep and the eggs touch each other at the sides. Under the microscope the light yellow coloured larvae may be seen inside them. At the free posterior end of the egg lies the cephalic end of the embryo and is deep brown in colour. The covering of the egg is not transparent enough to see clearly the inside of the developing eggs. The size on the 7th day increases 1·5 mm. to 1·8 mm. in length and 0·5 mm. to 0·6 mm. in width (average of 12 being 1·7 mm. by 0·6 mm.). On the 8th day the larvae hatch (Table I).

(iv) *Hatching.*

The larvae hatch both at night and in the day. It breaks through the egg by transverse opening, of which there is no previous marking. All of a sudden the

eggs burst and the anterior half of the body of the larva with the 3 thoracic legs is seen outside the egg. The larva is pale yellow and has the ocelli deep brown. The young larva pulls out very slowly the whole of its body by the movements of the legs. After coming out of the egg it stays motionless on the empty egg for about half an hour. By this time the ocelli darken and the colour of the body becomes deeper. The opaque dirty coloured empty egg case is left behind. The larvae do not hatch in the order they are laid. Banks (1956) also reported the emergence in *Coccinella 7-punctata* in the same manner.

(v) *The first instar larva.* (Fig. 3).

The newly hatched larva is pale yellow, elongated and somewhat C-shaped. Three pairs of thoracic legs are prominent with no tarsus and a single terminal hook. The appendages have short, scattered, unbranched bristles. The thorax is broader posteriorly than in the anterior region. They are 0.9 mm. to 1.2 mm. in length and 0.5 mm. to 0.7 mm. in width (average of 12 being 1.1 mm. by 0.5 mm.). Head has short, unbranched setae. Mouth is directed downward and the toothed mandibles are prominent. Ten abdominal segments are clearly seen under the microscope. Arranged on the mid-dorsal portion parallel to the grooves of all the thoracic and abdominal segments are a row of 6, branched, erect scoli. The two dorsal, two sub lateral on each side, and the last two laterals placed on the extreme lateral sides of the segments. The scoli have eight short acute branches, (Fig. 10). On the posterior end the scoli are smaller and less branched. The prothoracic sub-lateral scoli are unbranched. The antenna is three segmented and very short. The basal segment is broader than long and the distal segment is pointed, with long and simple hair on it. There are 3 prominent dark spots representing the ocelli on each side of the head. The anus is somewhat dialated disc-shaped and serves the chief adhesive organ. Ventral portion is light coloured and fairly smooth but has some scattered setae.

Movement of the 1st instar larva is by means of the post. adhesive structure and the thoracic appendages, very similar to the looping movement of a leech. When at rest it is seen nibbling the leaves here and there by its sharp mandibles. On the first day it rarely prefers to walk but whenever movement is observed it is very unsteady. On the second day the larva appears brown in colour with the naked eye. Under a microscope the body appears deep yellow and the bases of some of the branches of setae are seen brown in colour and also the intestinal track is seen almost coloured black and therefore the larvae are brown in appearance. Excreta is in the form of solid or yellow liquid drops. Movement is similar to that on the first day but sometimes the larva crawls also on its legs.

Until the fourth day the author noticed no change in the form of the body. After it has attached itself with its hinder end it only moves its body by means of its legs and keeps nibbling the leaf tissue for a fairly long time. During feeding they rarely move. For feeding it prefers more the mid-ventral portion of the leaf. It moults after the 4th day. (Table I).

(vi) *The second instar larva.* (Fig. 4).

The second instar larva is well developed and movements are more steady. They are 3.2 mm. to 4.1 mm. long and 1.5 mm. to 2.0 mm. in width (average of 12 being 3.7 mm. by 1.6 mm.). The prothoracic sub-lateral scoli are unbranched. It differs from the first instar larva as below :

The colour light yellow, the setae on the thorax and abdomen has 10 branches (Fig. 9) and the body is stout and increased in size. The ocelli are larger and more prominent. The antenna with the same number of segments and form

but the second segment is somewhat increased in length. Head and the appendages have short, stout unbranched and transparent bristles. On the thorax and abdomen the scoli are branched and some of them retain their dark stain. The legs are stouter with no tarsi and a terminal hook. The legs are the main locomotory organs but sometimes the post. adhesive structure is also used as in the previous instar. Both dorsally and ventrally the segments (ten in number) are marked by grooves. Some scattered setae are also seen on the ventral side. In this instar again no change is seen till the 5th day except increase in feeding. After the 5th day it attaches itself to the lower surface of the leaf by the same adhesive structure and moults (Table I).

(vii) *The third instar larva.* (Fig. 5).

The third instar larva is whitish-yellow and well built. It is 4.5 mm. to 5.5 mm. in length and 2.5 mm. to 3.2 mm. in width (average of 12 being 5.1 mm. by 2.8 mm.). It closely resembles the previous instar larva. The scoli on the thorax and abdomen have 10 to 12 branches (Fig. 8) and are longer than the previous instar, but the prothoracic sub-lateral scoli are unbranched. Head and appendages have simple setae and the leg has no tarsus but a single hook. Ocelli are conspicuous and antenna is fairly distinguishable. The thorax is broad posteriorly. The mouth is bent down with mandibles more developed having the inner toothed margins brown in colour. On the following days colour turns deeper and deeper. The branched setae become dark coloured and it feeds voraciously. They do nothing except biting the leaf. The faecal granules and the waste liquid drops pass out more frequently. The adhesive disc is more dialated, but movements are mainly by the appendages which have the same number of joint and hook as in the previous instar. The antenna is similar. It moults after four days (Table I).

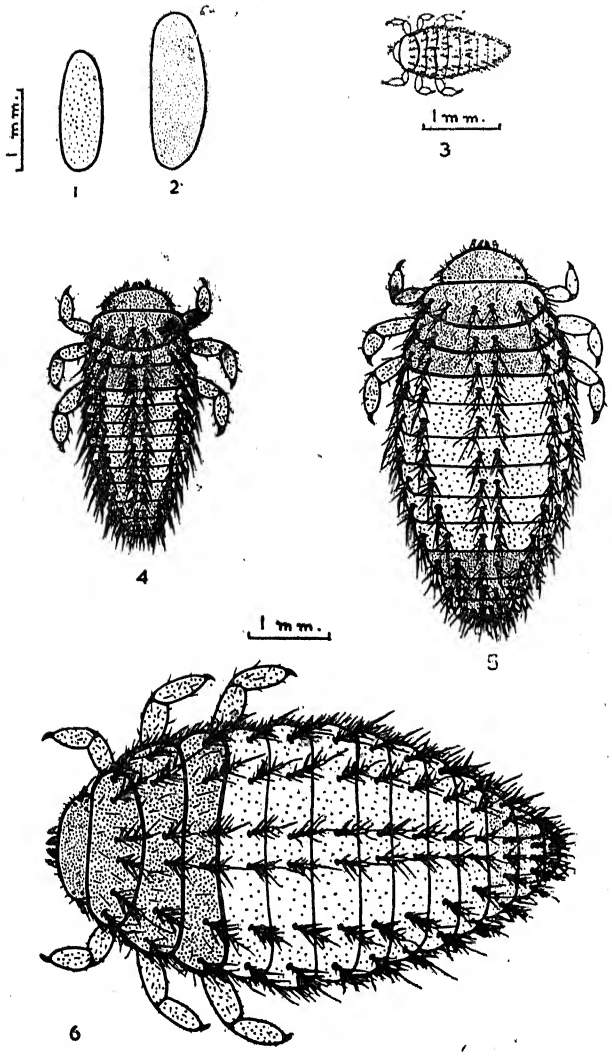
(viii) *The fourth instar larva.* (Fig. 6.)

The fourth instar larva is most developed. It is 6.9 mm. to 8.3 mm. in length and 3.4 mm. to 4.7 mm. in width (average of 12 being 7.8 mm. by 4.0 mm.).

It does the greatest harm by eating away the leaf. This stage is bigger than the adult insect. Kapur (1951) also observed the same in *Epilachna chrysomelina.* The body with the nacked eye seems to be much hairy and tapering posteriorly. The head and appendages resemble the previous instar. The triangular head is bent down. Three ocelli are clearly visible arranged in a triangle near the antenna. Antenna is three segmented. Basal segment is broader than long and the distal segment is longer than broad with apex broad and has a long setae along with few smaller ones placed apically. Mandible is curved and sickle-shaped with four or five teeth. The inner margin is serrated and coloured brown. The mandible is narrow distally.

On the thorax the scoli with 12 to 16 branches and 16 to 18 branches on the adomen (Fig. 7) but the prothoracic sub-lateral scoli are unbranched. Branches come out of the body of the setae from all sides and are of brown colour. Upper branches are longer than the lower. First thoracic segment is the shortest. Second and third are equal, less broad, but longer than the first thoracic segment. Ten abdominal segments are clearly seen. Second and the third abdominal segments are the widest. As we proceed to the posterior end the scoli become smaller and less branched. Thoracic mid-dorsal scoli are erect. Sub-lateral and lateral thoracic scoli are directed laterally upwards while the abdominal scoli are directed backwards. On the ventral surface the setae are almost transparent and the thoracic legs are similar in form.

PLATE I



EXPLANATION OF THE FIGURES

Plate I.

Figure 1. The egg (just laid).

Figure 2. The egg (on the 7th day).

Figure 3. The 1st instar larva.

Figure 4. The 2nd instar larva.

Figure 5. The 3rd instar larva.

Figure 6 The 4th instar larva.

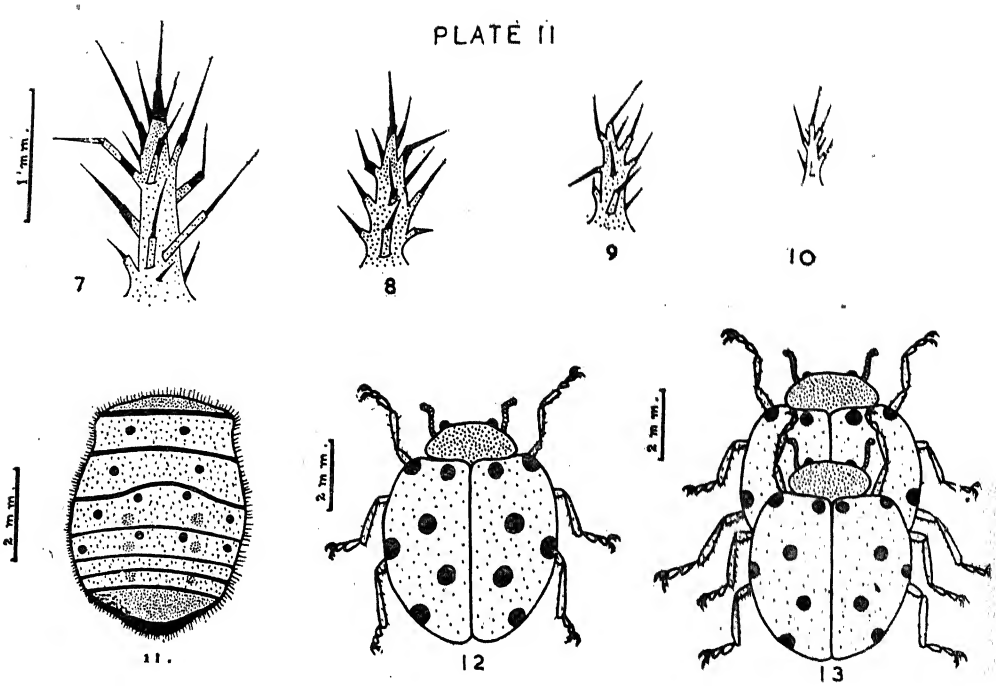


Plate II.

Figure 7. Branched thoracic scolux of the 4th instar larva.
Figure 8. Branched thoracic scolux of the 3rd instar larva.
Figure 9. Branched thoracic scolux of the 2nd instar larva.
Figure 10. Branched thoracic scolux of the 1st instar larva.
Figure 11. The pupa.
Figure 12 The adult.
Figure 13. Copulating adults.

Locomotion at this stage is both by the use of adhesive disc and legs. The larva feeds actively. After the fifth day they attach themselves to the leaf by means of the posterior adhesive disc and arrange the body in the form of a (,) or (c) for pupation (Table I).

(ix) *The pupa.* (Fig. 11.)

Pupa non-motile and 5·2 mm. to 6·3 mm. in length and 3 7 mm. to 4·2 mm. in width (average of 12 being 5·9 mm. by 3·8 mm.). After fixing itself, the last instar larvae cast off their exuvia completely, while in others only half the anterior end of the body is out. The exposed body is yellow and the segments are clearly marked off by constrictions. This portion has the pupal covering of a delicate transparent material covered with short unbranched hair. After four days the adults emerge throwing off the pupal covering (along with the fourth stage covering if it was retained during the pupation period) (Table I).

(x) *The adult.* (Fig. 12).

The freshly emerged adult is whitish-yellow. Neither the colour resemble the adult nor the spots are found. Eyes, antenna, legs and mouth parts all resemble the adult insect. Legs are prominent and have two terminal hooks. The antenna is ten segmented and curved. It is kept folded on the sides. It is smooth and without hair or bristles. The appendages have short unbranched bristles. The head is bent down. Thorax slanting and the abdomen convex. They are on an average 6·6 mm. long and 4·2 mm. broad. For 2-3 hours it moves haphazardly and does not feed. By this time the colour darkens and becomes light-chocolate. It also starts moving with speed. At the end of this period all of a sudden dark coloured spots are seen on the elytra. These marks are distinguishable into twelve black spots just like those of the adult and the colour of the elytra becomes deep chocolate after six hours. They start copulation two to four days after. (Table I).

SUMMARY

1. On an average a female lays from 31 to 52 eggs in 7 days.
2. The delicate barrel-shaped, white egg turn deep yellow on the 4th day, increase in size and becom brown on the 7th day.
3. The incubation period is about 8 days.
4. The newly hatched larva is the scarabaeoid type, with mandibulate mouth parts, 3 distinct thoracic legs, 10 segmented body with branched scoli on the dorsal surface.
5. The 1st, 2nd, 3rd and 4th instar larvae have 8, 10, 12 and 16 branches in the scoli.
6. Duration of each instar is four to five days and the different stage lareae are simimilar in shape and colour.
7. The number of branches in the scoli and the size of the body increase in the successive instars.
8. Pupa is immovable and curved or C-shaped.
9. Life-history is completed on an average in 44 days during March April.

TABLE I

Table showing the duration of different stages in the life-cycle.

S. No.	Stages	Duration in days		
		Minimum	Maximum	Average
1.	Preoviposition	4	11	7 Average of 12 insects
2.	Oviposition	2	7	5 „ „ 12 „
3.	Incubation	5	9	7 „ „ 85 eggs
4.	First instar	3	6	4 „ „ 45 larvae
5.	Second instar	3	7.	5 „ „ 44 „
6.	Third instar	3	6	4 „ „ 40 „
7.	Fourth instar	4	7	5 „ „ 49 „
8.	Pupal stage	3	5	4 „ „ 39 pupae
9.	Pre-copulation	2	4	3 „ „ 27 insects
			Total life cycle	... 44 days.

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